GUAM AGRICULTURAL EXPERIMENT STATION,
C. W. EDWARDS, Animal Husbandman in Charge.
Island of Guam.

BULLETIN No. 1.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

# PARA AND PASPALUM: TWO INTRODUCED GRASSES OF GUAM.

BY

GLEN BRIGGS, Agronomist.

Issued December 2, 1921

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

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## LETTER OF TRANSMITTAL.

GUAM AGRICULTURAL EXPERIMENT STATION,
*Island of Guam, September 11, 1920.*

SIR: I have the honor to submit herewith and to recommend for publication a manuscript entitled "Para and Paspalum: Two Introduced Grasses of Guam," by Glen Briggs, agronomist of this station.

Cattle raising has become one of the important industries of the Tropics on account of the climatic conditions and other natural advantages which favor it. In many instances, however, the industry can be properly developed only by a decided improvement in the size and conformation of the animal. One of the principal means of bringing about this improvement lies in the growing of more and better grasses, for the native grasses, especially those growing on the uplands in Guam, are inferior in nutritive value and also in quantity of feed produced during the dry season. *Paspalum dilatatum*, as a pasture grass, and *Panicum barbinode*, as a soiling and pasture grass, two grasses introduced into Guam by this station, have been found admirably well adapted to local conditions.

It is hoped that the data contained in this bulletin will be of value not only to live-stock raisers of the South Pacific Islands, but likewise to those living in the many other localities of the Tropics and subtropics suitable for the growing of these grasses.

I recommend that this manuscript be published as Bulletin No. 1 of the Guam Agricultural Experiment Station.

Respectfully,

C. W. EDWARDS,
*Animal Husbandman in Charge.*

Dr. A. C. TRUE,
*Director, States Relations Service,*
*Department of Agriculture, Washington, D. C.*

Publication recommended,
A. C. TRUE, *Director.*

Publication authorized,
HENRY C. WALLACE,
*Secretary of Agriculture.*

# PARA AND PASPALUM: TWO INTRODUCED GRASSES OF GUAM.[1]

CONTENTS.



## INTRODUCTION.

Among the earliest experiments undertaken by the Guam Agricultural Experiment Station were some with grasses introduced to replace the native species, which are poor in quality and often deficient in quantity. Pastures are the foundation of animal husbandry, and grasses form the basis of permanent pastures. The development and expansion of animal industry in Guam depends upon the production or introduction of grasses suitable for grazing purposes. After a great many trials covering the work of several years at the station it has been fully proved that the native grasses of Guam are lacking in the palatable and nutritive qualities essential to extensive animal production. Very satisfactory results, however, have been obtained from certain introduced grasses, which enable more stock to be carried on given areas than the native grasses will support.

Guam needs grasses that will insure the farmer against sacrificing his live stock when climatic conditions prevent the growing of most of the local grasses and forage crops. Such grasses are to be found in the improved pastures planted to introduced grasses. Inasmuch as long dry seasons are of frequent occurrence in Guam, the amount of feed furnished by the native pastures is always uncertain. The ability of certain introduced grasses to furnish a large amount of feed during the drought makes them much superior to the native grasses, which are apt to suffer and die during these periods.

It is to the interest of every stockman to increase the carrying capacity of his pastures by planting the best grass obtainable. Certain necessary characteristics of a valuable grass are: (1) Satisfactory yields or carrying capacity; (2) high feeding value; (3) ready means of propagation or reproduction; and (4) adaptability to local conditions.

[1] The data herein presented are compiled from the records at this station, and cover the work of many years. The author, who has been connected with the station only since March, 1917, wishes to give credit to C. W. Edwards, animal husbandman in charge of the Guam station, for much of the data obtained in connection with the feeding tests.

The first requisite is almost self-evident. The labor and expense involved in planting would be useless unless the grass proved better in yield or carrying capacity than the native forage at hand. The second requirement takes into consideration the palatability of the grass, or likes of the animal. The grass should be succulent, free from woodiness, and from any injurious physiological property tending to spoil the milk of the cattle, or to poison them. In composition it should show a large percentage of protein and fat. As regards the third essential characteristic, viz, means of reproduction, the grass should have abundant, easily-gathered seed, or there should be a means of readily and easily obtaining propagation material by vegetative methods. Finally, the grass must be able to maintain itself under the prevailing soil, climatic, and cultural conditions, and yet not be troublesome as a weed.

The Guam station has devoted much time and attention to testing different kinds of grasses most likely to meet the needs and conditions of the Guam farmer and has found Para and Paspalum grasses much superior to the native or other introduced grasses tested. The station is now advocating the more extensive planting of these two grasses for pasture and forage purposes.

At present the production of meat in Guam is not adequate to meet the demands of the population, nor is it likely to be for some time to come; and the requirements of the United States Navy and Marine detachments and other non-native residents seem to assure a market for future maximum production. The local supply of meats is inferior to the imported, largely because of lack of nutritive forage. The introduced grasses should be encouraged in order that this difficulty may be overcome. They have a larger carrying capacity than the native grasses and, being more palatable and nutritious, would cause a quicker and more even maturity of the animal, thus greatly aiding in the production of good meat.

## GUAM CONDITIONS.

*Location.*—Guam is the extreme southern island of the group of islands known as the Marianas, sometimes incorrectly called the Ladrones. It is the largest of the group and comprises an area estimated to cover 225 square miles, probably less than one-fourth of which is under cultivation. Apra Harbor, near which the Guam station is located, is in longitude 144° 39′ 42″ east, latitude 13° 26′ 22″ north. Guam is 1,506 miles east of Manila, 3,337 miles southwest from Honolulu, 5,053 miles from San Francisco, and 7,988 miles from Panama. Before the war the island was reached by Army transports which sailed once a month from San Francisco to Manila via Honolulu. Since the war Navy transports also stop at Guam about every six or eight weeks. Other vessels stopping at this port

are schooners from the United States and Japan, and an occasional United States collier.

The agricultural experiment station of the United States Department of Agriculture upon this island is the most southern and only oriental Federal station maintained by the department. The Navy Department has a naval station, a high-power radio, and a coaling station in Guam, and a trans-Pacific cable company operates an important cable station here.

*Climate.*—The climate of Guam, while strictly tropical, is tempered by a brisk trade wind, which blows throughout the greater part of the year from east and northeast. The seasons are rainy and dry, although not so distinctly defined or uniform in character as in many parts of the Tropics. Observations at the station show that the temperature is fairly uniform the year round. Table 1 gives condensed data on the temperature for the two years 1918 and 1919:

TABLE 1.—*Summary of temperature for the months named, 1918 and 1919.*

| Fiscal year. | Mean annual temperature. | Monthly temperature. | | Temperature. | |
|---|---|---|---|---|---|
| | | Mean maximum. | Mean minimum. | Maximum. | Minimum. |
| | ° *F.* | ° *F.* | ° *F.* | ° *F.* | ° *F.* |
| 1918 | 80.88 | May 82.27 | Jan 79.49 | July 9 97.5 | Jan. 3 68.0 |
| 1919 | 81.94 | May 83.37 | July 81.21 | May 4 99.0 | Jan. 21 69.0 |

One of the most important factors bearing on the production of grasses is the rainfall and its distribution during the year. In Table 2 are given the data for the years 1918 and 1919, and a summary of the average monthly rainfall for the years 1907–1919. The year 1919 was somewhat abnormal in Guam, owing to the occurrence of a typhoon and a severe drought.

TABLE 2.—*Rainfall for the fiscal years 1917–18 and 1918–19, and summary of the average monthly rainfall, 1907–1919.*

| Month. | Fiscal years. | | Average rainfall, 1917–1919. | Average, 1907–1919.[1] |
|---|---|---|---|---|
| | 1917–18 | 1918–19 | | |
| | *Inches.* | *Inches.* | *Inches.* | *Inches.* |
| July | 8.95 | 30.53 | 19.74 | 13.59 |
| August | 15.13 | 12.27 | 13.7 | 14.75 |
| September | 20.94 | 16.9 | 18.92 | 15.9 |
| October | 11.71 | 12.6 | 12.15 | 13.76 |
| November | 6.29 | 6.26 | 6.27 | 8.25 |
| December | 2.58 | 3.05 | 2.81 | 5.48 |
| January | 7.62 | 1.65 | 4.63 | 2.55 |
| February | 8.53 | .91 | 4.72 | 3.06 |
| March | 2.67 | 1.42 | 2.04 | 2.93 |
| April | 3.65 | .61 | 2.13 | 1.72 |
| May | 5.1 | 1.03 | 3.07 | 3.81 |
| June | 8.05 | 8.54 | 8.29 | 5.06 |
| Total | 101.22 | 95.77 | 98.47 | 90.86 |

[1] Taken from Pacific Commercial Cable Co.'s records at Sumay.

Table 2 shows that the rainy season usually begins in June and continues to November, but that the heavy rainfalls occur in July, August, September, and October. The dry season is from January to May, during which time local, in some cases very light, showers occur. At times, however, good growing weather continues throughout the period. It is during the dry season that the need of better pastures and forage is most keenly felt.

*Soils.*—The soils of the island are largely of volcanic and coral origin and present many distinctive characteristics peculiar to Guam. The soils in different localities vary from a fine coral sand along the beaches, light reddish loams and clays on the mesas or uplands, to deep black, heavy clay along the rivers and in the deeper valleys. Some soils react to acidity tests, but in general they are basic as there is much limestone on the island. Organic matter is present in limited quantities in most soils, and the addition of stable manure has helped greatly to increase crop yields.

After heavy rains many of the soils become compact and dry out in hard masses, forming great cracks. These masses become almost solid unless they are cultivated before thoroughly drying out. During periods of heavy rains the lowland soil remains in a puddled [2] condition. The areas intermediate between the lowlands and the uplands often present a peculiar physical condition, remaining loose and friable at the surface, but having a substratum of heavy, almost impervious subsoil. Analyses of the two soils show them to be very much alike, both being a loam underlain by clay. Table 3 gives the results of chemical analyses of some typical lowland, upland, and strand soils.

TABLE 3.—*Average chemical analyses of some soils of Guam.*[1]

| Constituent. | Lowland. | Upland. | Strand. |
|---|---|---|---|
| Silica ($SiO_2$) | 44.08 | 0.98 | 2.95 |
| Titanium ($TiO_2$) | .85 | 2.08 | .27 |
| Iron ($Fe_2O_3$) | 14.70 | 20.32 | 5.17 |
| Alumina ($Al_2O_3$) | 21.92 | 40.44 | 8.24 |
| Manganese (NnO) | .30 | .31 | .21 |
| Lime (CaO) | .89 | 2.44 | 31.86 |
| Magnesia (MgO) | 2.54 | .10 | 1.01 |
| Potash ($K_2O$) | .58 | .12 | .21 |
| Soda ($Na_2O$) | .32 | .40 | .46 |
| Phosphoric acid ($P_2O_5$) | .07 | 1.84 | 2.57 |
| Sulphuric acid ($SO_3$) | .14 | .52 | .71 |
| Nitrogen (N) | .31 | .49 | .99 |
| Loss on ignition | 13.08 | 30.01 | 48.47 |

[1] Analyzed by the Bureau of Soils, U. S. Department of Agriculture.

*Native grasses.*—The northern end of the island is largely covered with forests and contains some pastures consisting mostly of brush and a few forest grasses. The southern end of the island is broken

[2] That clay which is extremely sticky and so closely compacted that it becomes impervious to rain.

by numerous hills that are covered with uncultivated grasses. The principal grass of the savannas is the sword grass (*Miscanthus floridulus*), locally known as "neti." It is a coarse, woody grass and while young and tender furnishes fairly good pasture for native cattle and carabao; however, it soon becomes dry and fibrous. The awn grass (*Andropogon aciculatus*), known as "inifuk," grows along the semilowlands, rivers, valleys, and forest lines. This is a splendid grass, but has the disadvantage of being provided with adherent awns, which collect on the clothing of those coming in contact with it. These awns also pierce the legs of horses causing, in the case of animals constantly on pasture, sores, which, however, quickly heal when the animals are removed to land free from this species.

## PARA GRASS (PANICUM BARBINODE).

### BOTANY.

Para grass is known scientifically as *Panicum barbinode*. While some doubt has been expressed regarding the proper name of this grass, it seems to be almost universally known as *P. barbinode*.[3] It has been known under a number of different names in as many different countries. Common names, other than Para grass, are Panicum grass in Hawaii, malojillo in Porto Rico, Spanish grass or yerba del para in the Philippines, and Mauritius grass, Scotch grass, and water grass in Australia. It is probably a native of Brazil, whence it spread throughout most of the Tropics. Para grass is especially adapted to wet or moist land, though it stands drought remarkably well considering its habit of growth.

Para grass is a coarse perennial grass having prostrate runners or stolons about the size of a lead pencil. (Pl. I, fig. 1.) These runners often grow from 8 to 30 feet long, and when the ground is well covered with them, the shoots turn upright. Roots are sent out at each node or joint where the runners come in contact with the wet ground. The root system is fibrous and the plant is a shallow feeder. The grass is a very vigorous grower and soon covers the ground. Under favorable circumstances, it makes thick, rampant growth from 2 to 5 feet high, depending upon the fertility of the soil. At this station it has, when properly supported, reached a height of over 15 feet. The sheaths and nodes are decidedly pubescent. The inflorescence or seed head is a spikelike raceme. (Pl. I, fig. 2.) The leaves are rather coarse, being about half an inch wide and seldom over 12 inches long. They are attached to the stem by a comparatively long sheath.

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[3] C. V. Piper, agrostologist of the Bureau of Plant Industry, U. S. Department of Agriculture, says: "The proper name of Para grass is *Panicum barbinode*. *Panicum muticum*, which was applied to a grass in Ceylon, is, with scarcely a doubt, the same species. *Panicum molle* is an entirely distinct species of grass but which some botanists at one time supposed was the same as Para grass."

### INTRODUCTION INTO GUAM.

Para grass has been distributed over the Tropics and extends well up into the semitropical countries. It is found in Australia, Ceylon, Philippines, Mexico, British Guiana, Cuba, Porto Rico, South Sea Islands, and other tropical countries, as well as in the Gulf States of the United States. In May, 1910, it was introduced into Guam by this station from the Hawaii Agricultural Experiment Station, where it had been brought from the Fiji Islands in 1902 under the name of *Panicum molle*, by which name it was later identified by the Philippine Bureau of Science. However, both here and at Hawaii it is now known as *Panicum barbinode*.

### ADAPTATION TO GUAM.

Para grass has proved to be well adapted to Guam climate and to certain soil conditions. During the last 10 years it has furnished the bulk of the forage fed to the animals at the station. In years when the weather was so dry that the native pastures dried and burned, the Para grass at Piti and Cotot tided the stock over very critical periods until the rains started. The grass has been planted in various places on the island and in all cases has made satisfactory growth.

### USES.

Para fills two important needs of the island, that of pasturage and that of a soiling crop.[4] When first introduced into Guam, this grass was largely handled for rough forage, but it is now also utilized very satisfactorily as a pasture grass. No other cultivated crop at the station has been eaten with the same persistence and regularity in all stages of maturity. Hay is not made on the island because the grass grows the year round and furnishes a succulent forage at all times. It would be very difficult to cure hay so that it will keep in storage because the high humidity of Guam prevents the stems from thoroughly drying.

The dry seasons have especially emphasized the value of Para grass as a soiling crop for Guam. Practically all the native grasses fail during these periods, which frequently occur between March and July. On the lowlands Para grass is cut about once in every five weeks. The need of frequent cuttings was clearly demonstrated during 1918, when only 5 or 6 cuttings were made owing to wet weather, lack of labor, and less stock than usual to feed. The grass was allowed to produce seed, and consequently became very coarse, forming a thick, dry, matted growth near the ground, through which it was difficult to run a mower and which made a poor grade of forage. After the matted portion was removed the grass quickly

[4] A soiling crop is forage cut in a green stage and fed to animals which are in stalls, inclosures, or tethered by ropes.

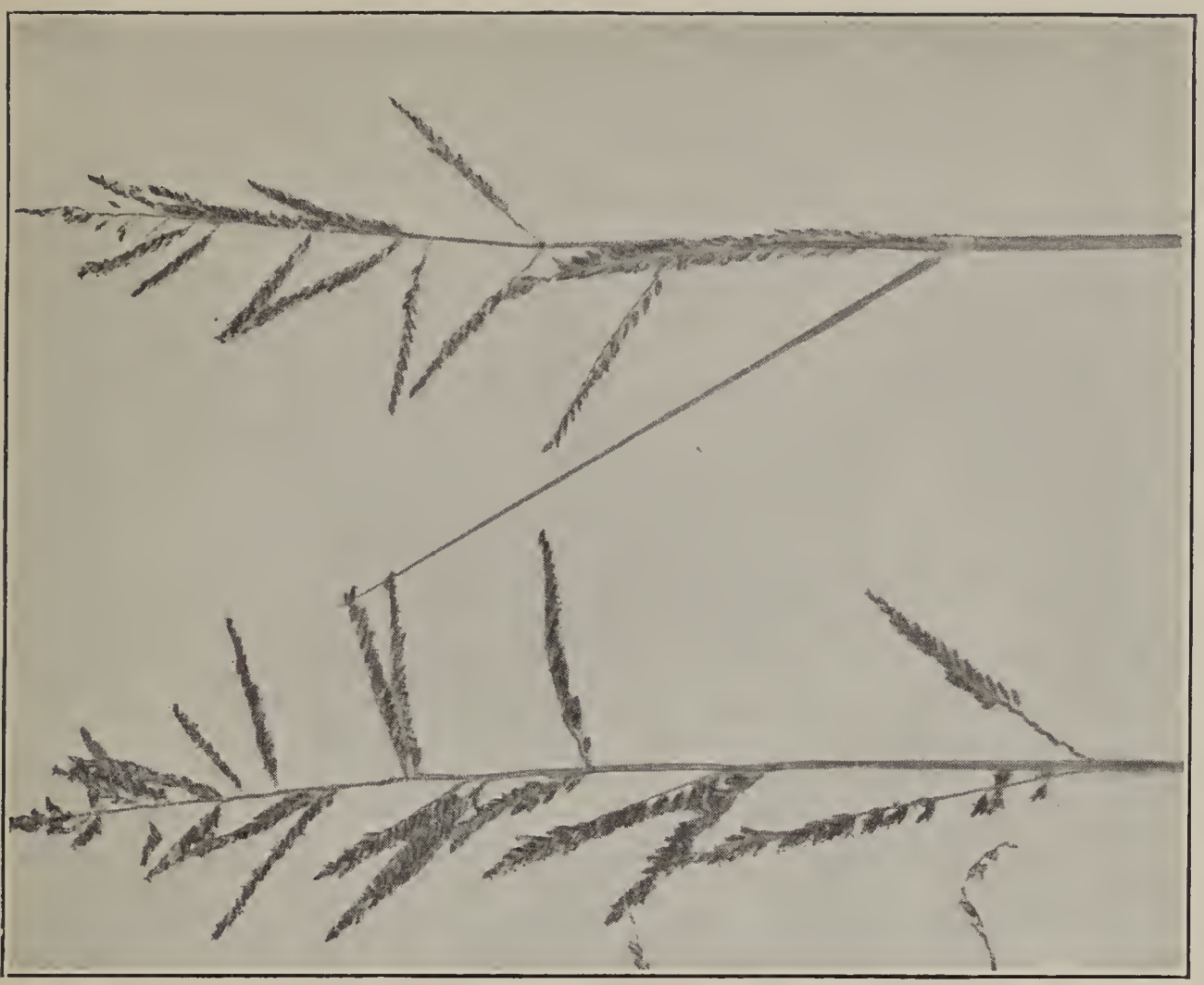

FIG. 2.—PARA GRASS IN FLOWER AND SEED.

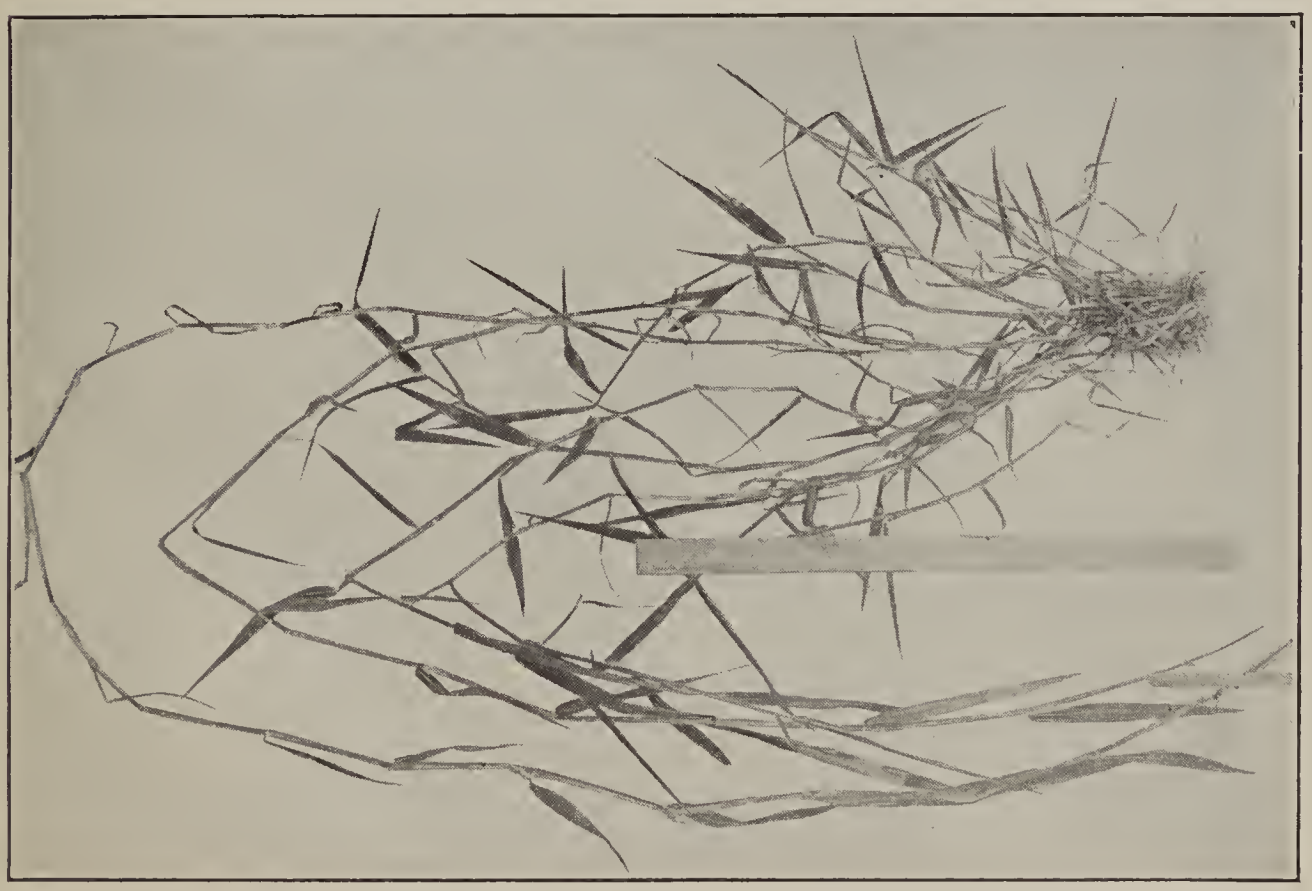

FIG. 1.—PARA GRASS SHOWING ROOTS, STEMS, AND LEAVES.

FIG. 1.—PARA GRASS PLANTED ON CLEARED LAND AT COTOT.

FIG. 2.—A GOOD GROWTH OF PARA GRASS ON UPLAND.

put out new growth and again was easy to cut, which shows that frequent cuttings are necessary if the best results are to be obtained, especially during the wet weather, or for forage production. Para grass is excellent as forage when it has made good growth and the stems have not become hard and woody. In this stage it can be used for feed with very little waste. At the Cotot stock farm a heavy matted growth was burned off, the dry undergrowth catching fire readily and having no apparent ill effects on the next crop. As a soiling grass, Para is very easily managed; it is long enough to hang together when handled with a fork, yet it is not long enough to necessitate dragging it apart when pitching it on the wagon or into the barn.

The experience with native grasses at the Cotot stock farm has clearly demonstrated the necessity of substituting for them the proved introduced grasses, Para and Paspalum. Had it not been for the few acres planted to Para grass during the first two years of its trials at that farm, it is doubtful if the cattle would have survived the dry season.

## WHERE TO PLANT.

Many places in Guam may be profitably planted to Para grass. It is, however, generally thought that the best results are secured from low, wet lands, and Para grass has been credited with completely drying out swampy lands. In this bulletin the places of planting are considered under five headings—lowlands, new clearings, old land, uplands, and coconut plantations.

*Lowlands.*—Swampy lands greatly favor growing conditions because they remain wet throughout the year. Lowlands also provide for the largest yield on the least area of ground and are invaluable for the production of forage during the dry season when there are so few other grasses. Para grass survives after having been inundated for periods of a month or more and is able to grow on land that would be good for nothing else most of the year. Most of the villages of Guam are near some low, swampy areas that would be ideal for the production of this grass. These places are so situated that the cut grass would have to be hauled only a short distance for feeding the work animals of the village, or they could be pastured upon the grass in the field. The south end and west side of the island contain many abandoned rice fields that could be made to furnish an abundant supply of grass for soiling purposes or for pasturage. Were these fields planted to Para grass rather than to native grass, they would furnish much more feed for the village work animals pasturing on them than they now yield.

*New clearings.*—Many locations are highly desirable for the raising of some forage crops, but can not be used because of certain difficulties. Areas from which forests have recently been cleared are often

so full of stumps and roots that they can be planted to other crops and cultivated only with much trouble. It is, of course, impossible to plow or use modern machinery until the stumps have well rotted or have been removed. On such areas the machete and fosiño should be used to clean the land so that the grass may become established before other plants spring up. After the grass is well established it will hold its own, keeping down and smothering out other growth. At Cotot a large area of this kind of land, much of which is upland, has been planted to Para grass and has furnished an abundance of feed, requiring only a minimum amount of labor after being started. (Pl. II, fig. 1.) New clearings on the savannas where grass and small brush are growing can best be planted to Para grass if they are treated like the old lands.

*Old land.*[5]—The quickest way to start Para grass is to plant on old land that can be plowed and put into well tilled condition. By smoothing this ground down level it is possible to use a modern mower on it; this greatly facilitates cutting and saves much time and hand labor when the grass is to be used as a soiling crop. Old land is the most practical place to plant Para grass when it is to be grown in large quantities for fodder.

*Uplands.*—Though Para can be planted on the hills, it is not regarded as good practice to do so unless the location is near a small stream or a spring. Near Upi, on the ranch of Capt. E. L. Bisset, Para grass seemingly made good growth, though planted on high and dry land. The same is true at Cotot. (Pl. II, fig. 2.) It is believed that general planting for pasture on the hills and savannas is best done with Paspalum grass because that grass seems better adapted to these conditions. While Para grass would make little or no progress on the red clay uplands, it is likely that Paspalum would do fairly well on them.

*Coconut plantations.*—Opinions differ in regard to the value of planting Para grass among the trees on a coconut plantation. No actual experiments have been carried on for any length of time, but for nearly three years this station has been conducting tests by intercropping young coconut trees[6] with Para grass. The trees between which Para was not allowed to grow to any extent are considerably larger and more vigorous than the trees grown on the plats where the grass was allowed to encroach upon the root zone. The grass should not be pastured in young plantations because animals are fond of young coconut leaves and readily destroy them.

In Panama and Mexico[7] Para grass for pasture purpose is recommended for planting between the coconuts. On many estates in

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[5] Old land is that which has been cleared and cropped for several seasons and is generally free of obstructions.

[6] Guam Agr. Expt. Sta. Rpt. 1916, p. 38.

[7] H. H. Smith and F. A. G. Pape. Coconuts: The Consols of the East, pp. 117 and 155.

other countries this practice has been very satisfactory and the cattle have been found to thrive and become hardier. On others it seems to have met with much objection. Further experiments are necessary with both young and mature coconut trees before conclusive evidence can be obtained. It would seem, however, that Para grass, instead of the volunteer native grass or second-growth brush which are often allowed to spring up, could be pastured without detriment to coconut trees that are mature.[8]

### WHEN TO PLANT.

The time of planting Para grass depends wholly upon climatic and soil conditions. To enable the grass to make a rapid start, it is necessary that the ground be at least moist. In general, the best time to plant is at the beginning of the rainy season. The farmer is then certain that the plant is provided with water sufficient to enable it to develop a good root system and become well established before the dry season starts. The earlier in the rainy season the grass is planted the sooner it will become available for grazing or feeding purposes. While a good stand can be secured from later plantings, it is probable that the ground will not be completely covered with grass, but will require weeding, and the grass will hardly be well established before it is wanted for forage.

Plantings may be made during the dry season, in which case the land is plowed, so that furrows can be laid out. Such plantings, however, depend entirely upon conditions. The stems may be planted at any time if irrigation is available; otherwise, it will be necessary to take advantage of any precipitation occurring before the regular rains start. Very often plantings made during such periods provide pasture or a soiling crop during the rainy season. Under extremely favorable conditions Para grass may cover the ground and reach a height of 3 feet within two months after being broadcasted or planted in rows. More often, however, it requires about four months to become well enough established for pasturing or for use as a soiling crop.

### HOW TO PLANT.

*Preparation of the soil.*—Whenever it is possible to do so, land should be as thoroughly prepared for Para grass as for any other field crop. It is a great mistake to think that because grass is such a common and hardy plant it does not need a well-prepared seed bed. Young grass roots are tender and sensitive and extra trouble taken in the preparation of the land will be repaid by the results. When the grass is to be cut with a mower for forage, a finely prepared, compact

[8] In view of the difference of opinion regarding the growing of grass on coconut plantations, the writer suggests the planting of legumes, such as cowpeas, velvet beans, and the like as a cover crop. These produce an excellent forage, are harmless to the trees, and, by the action of nitrogen-fixing bacteria, which store nitrogen in the root tubercles, greatly improve the fertility of the soil.

surface should be made in order to produce an even, uniform growth of grass and a smooth field for the perfect running of the mower. When the grass is intended for pasture, the ground should be just as carefully prepared so as to give the grass a better opportunity to get the start of weeds. The proper preparation can be secured only by the use of modern farming implements, such as a steel plow and a spike-tooth or a disk harrow. The best time to plow is after the rains start, but before they become heavy. The ground at this time is in a friable condition and easy to manage. The dry season hardens the ground, and if it is plowed then the surface is left very cloddy. This makes it difficult to work the soil down into a suitable seed bed. However, to avoid rushing the work and delay in planting, it is often advisable to break the ground early and leave the soil fallow until after the rains start; it is then easily worked down with a spike-tooth or disk harrow. Working the soil after the rains are well started and the soil has become filled with water causes it to become puddled or run together. This shuts out the air and causes the soil to crack when it begins to dry.

### Propagation.

Several ways of propagating Para grass were tried at the experiment station with more or less success. These included use of seed, roots, cuttings, stalks in furrows, and stalks broadcasted.

*Seed.*—Para grass produces seed during the rainy season from August to December. Much of the seed is not well filled or viable. In tests in flats in the plant house it was estimated that about 25 per cent of the heaviest seed germinated. The plants are very small and tender when young and grow slowly for some time. Planting seed has been found to be the most unsatisfactory of any of the methods of propagating Para grass tried at the station. In the first place, good seed is not plentiful and takes time to gather; the heads must be picked by hand or the ripe seeds stripped from the stalks as they mature. The seed bed should be prepared very carefully, because it requires a long time for the seed to germinate or the young plants to grow to any size; in the meantime, weeds have splendid chance to start and crowd out the young grass. Propagating by seed would be the best method for places requiring long-distance transportation, or for inaccessible places where the plants could not be carried. It should then be planted in well-prepared beds and given special attention until enough plants are grown for propagation by other means. All places in Guam can be reached by bull trail and propagating by seed is not necessary.

*Roots.*—The station first used roots as a method of propagating Para grass. The following extract[9] is given to show how quickly Para

[9] Guam Agr. Expt. Sta. Rpt. 1911, p. 11.

grass became established and available for distribution by the use of the root method in Guam:

The first introduction of this grass was made in May, 1910, when 25 root clumps were received from the Hawaii Agricultural Experiment Station. So rapid has been the propagation that several large wagonloads of roots have been distributed in addition to material required for planting a plat of 1 acre on the station grounds. At the close of the year the station had available plants sufficient to plant another plat of 2 acres, and this ground was in a state of preparation awaiting only the advent of favorable weather when the planting could be safely made. Para grass grows rapidly, sending out long runners in every direction, and these runners coming in contact with the soil send out roots at the nodes, forming new plants. Owing to this habit of growth, plants may be set from 5 to 10 feet or even at a greater distance apart, and under favorable conditions a thick sward will be grown in a comparatively short time. When planted at wide intervals early growth is of low, trailing decumbent nature; but when the surface is once covered, an upright habit of growth is assumed, rendering the crop easily cut and well adapted for soiling purposes.

It has since been found that methods other than propagating by roots are more practical and less expensive when the supply of grass is near at hand.

*Cuttings.*—Cuttings are made by dividing the stems into sections varying from 8 to 12 inches in length. Two or three joints or nodes are left to each piece of grass. These are placed in the ground 3 to 6 feet apart, so that one or two joints are covered with soil. From these joints roots soon put out and begin to grow. This method has been successful, but it is almost as slow and expensive as planting the roots. However, it has the advantage in that the same number of plants cover a much greater area.

*Stalks in furrows.*—Planting stalks in furrows that have been opened by a plow has been one of the most satisfactory methods of growing Para grass in Guam. Up until 1916 the experiment station planted most of this grass by the root method. Observations on the quick growth of refuse pieces of Para, mixed with manure from the barns, led to a trial of planting the grass stems. Furrows were laid off about 3 feet apart across the whole field. Mowings of Para grass were then scattered thickly in the furrows and covered with soil which was slightly packed down, so that the field would be level. This method is the surest and probably the quickest means of establishing Para grass, and is generally followed where it is possible to till the soil. It has many advantages over the methods previously mentioned. It is easier and less expensive than the other methods, because it permits of more animal-drawn machine work and requires less hand labor. The work can also be accomplished in a short time and on a more extensive scale. A quick start and a good stand are insured, since the nodes, each of which starts a shoot of grass, are all in close contact with the soil.

*Broadcasting.*—During the past two years, at the Cotot stock farm, sowing the grass stems or stalks on the surface of the soil during the

rainy season gave very satisfactory results. In areas where new clearings have been made, the stems can be scattered on the soil without other preparation. While this at first glance seems to be contradictory to former statements made in regard to soil preparation and a makeshift method of planting, examination shows that a large part of the soil in wooded areas is very loose when first cleared. This is probably the most satisfactory and perhaps the quickest method of growing this grass when time and labor involved in clearing are not considered. It requires, however, larger quantities of grass stems than any of the other methods.

*Legumes* [10] *in combination.*—Growing legumes with grass is not a method of propagation, yet it is a means of producing a larger yield and a better grade of forage than is ordinarily obtained. The need of nitrogenous feeding stuffs which can be successfully produced on the island has been keenly felt in the past. Grass is not, however, wholly satisfactory as an entire forage ration. To fill this want velvet beans and cowpeas were planted in newly started Para grass or just after it was cut. The seeds were sown broadcast or in rows while the land was being prepared, or in established fields having no preparation other than making a hole in the sod with a sharp-pointed stick. Grown in this way the vines do not produce as much forage or grow as vigorously as when grown by themselves, but they produce an excellent grade of forage.

All legumes are soil builders, as the bacteria living in symbiotic relation with these plants extract free nitrogen from the air and store it in the tubercles on the roots. The cultivation of legumes, therefore, adds to the fertility of the soil and greatly increases the total yield of forage. Legumes when mixed with Para grass make the feed of better quality by adding to the ration protein, which is especially valuable for all growing animals. The one disadvantage of this combination is the necessity of planting the legumes after every cutting of Para grass; yet, it requires very little labor, and more than justifies the time and trouble given to planting. Velvet beans were found to do well when planted 3 or 4 feet each way, while cowpeas did well when planted not more than 2 or 3 feet apart each way.

The following extract is taken from Farmers' Bulletin No. 509 [11] and confirms the above statement:

> A field which is well set with the [Para] grass may be kept in good condition almost indefinitely if it is given a shallow plowing in the spring and then seeded with cowpeas. The grass will then make a vigorous growth and the first cutting will be ready when the peas begin to mature, the mixture making a hay of choice quality and a better yield than when the grass is grown alone. The pea vines will make no further growth, but the grass will make two to four later cuttings, each heavier than if the ground had not been plowed.

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[10] Legumes are plants belonging to the pea and bean family and contain large amounts of protein, which is one of the most important elements in all animal food. The legumes most commonly grown in Guam are mung beans, peanuts, cowpeas ,soy beans, velvet beans, tangantangan, and garden beans.

[11] Tracy, S. M. Forage Crops for the Cotton Region. U. S. Dept. Agr., Farmers' Bul. 509 (1916), p. 11.

At the Porto Rico Agricultural Experiment Station, D. W. May found that "the velvet bean improves the soil, greatly increases the production of forage, and makes a good combination with Para as a feed," when planted by making holes in the sod with a sharp stick, as described above.

### COST OF PLANTING.

One of the first things to consider in changing a system of grazing is the cost of establishing the new system. This cost has been carefully worked out on a large scale in the different plantings at the station. All the data have been based upon the cost of digging and planting the roots, exclusive of plowing, or in cutting and planting the stems. Generally, the farmer does not consider the personal labor he puts on his place. The cost of planting in Guam is usually very small, as a supply of roots or stems can be obtained free of charge from the station, either at Piti or at Cotot. Table 4 gives the cost of transplanting, or of cutting and planting Para grass, including transportation and other work necessitated by the method used.

TABLE 4.—*Cost of planting Para grass at the station.*

| Test No. | Material used. | Distance of planting. | Cost per acre.[1] |
|---|---|---|---|
| 1 | Roots | 3 to 5 feet apart in rows about 3 or 4 feet apart | $10.00 |
| 2 | do | 2½ to 3 feet each way | 9.80 |
| 3 | Stalks | do | 7.20 |
| 4 | Stalks in furrows | 3 feet apart | 3.60 |
| 5 | Stalks broadcasted | | 3.00 |

[1] Laborers received 80 cents a day; a man, with carabao and plow, received $1.50 a day.

Tests 1 and 4 were made at the Piti station on land that had formerly been planted to other crops. After the land was prepared for planting, furrows were laid out with a plow. The other tests were made at the Cotot stock farm on land that had been recently cleared but not plowed because it was in a loose condition. All tests were made under practical field operations and may be considered applicable to similar farm conditions. A good stand was secured from each test, but some took longer than others to spread and to become available for pasturing and soiling purposes. Test 4 was made under ideal conditions, and at the end of six weeks the ground was covered with grass 3 feet high. Test 1 required 4 months to reach that stage. The cost of tests 3 and 5 probably could have been reduced somewhat had a mower rather than machetes been used to cut the grass.

These results indicate that the cost of broadcasting is less than one-third that of planting roots, less than one-half that of setting stalks in the ground as cuttings, and only five-sixths that of planting the grass in furrows. The cost is such a small matter in comparison with the gains accruing from the grass as an improved forage that it should not be considered a hindrance to increased plantings.

### HARVESTING.

Para grass may be harvested at any time. It should be cut while still tender and succulent, usually any time before it matures seed. Generally it is cut when it reaches a height of 30 or 40 inches. When the grass is allowed to stand too long before cutting the stems become coarse and unpalatable. From 3 to 10 cuttings a year are possible, though this depends upon the fertility of the soil and the stage of growth when cut.

The method of harvesting depends a great deal upon the equipment with which the farmer has to work. It is needless to recommend a modern 3 or 4 foot cut mower to those who have seen the efficiency of these machines at this station or at the naval Government farm. Where anything except the smallest fields are to be cut, this mower is undoubtedly a great labor and time saver and soon pays for itself. On the smallest fields, and where it is not practical to have a mower, the farmers use a machete to cut the grass that is to be fed to the work animals. However, most of the farmers near the villages have only a few animals, which are tethered in the fields as much as possible. This practice saves the expense of cutting the grass. The large ranches are some distances from the villages and the animals are allowed free range on them; consequently, the forage is not cut in large quantities.

### YIELDS.

Yields of Para grass are very heavy compared with those of other forage crops. The grass is a vigorous grower and produces an abundance of forage. The lowest yield from unfertilized land at this station for a period covering over 50 cuttings, averaged 12.16 tons a year. A great number of plats gave much higher returns. Fertilizers, manures, and plowing greatly increased yields.

The following is an account of an experiment giving details about yields, effect of fertilizers, and plowing tests. The report of the first year's work [12] is quoted herewith in order that one may get a clearer perspective of the working plan.

*Experiments in renovating Para grass fields.*—A field of approximately 3 acres was chosen for this work and planted in 1911. An application of nitrate of soda was made in 1913, but there are no data available as to the amount applied or its effect. During the fiscal year 1915, it was noted that the production was rapidly declining and that weeds and native grasses were making inroads upon the stand of the Para grass. The field was consequently laid out in 8 plats for experiment. The following table gives the number of cuttings, treatment of each plat, and yields per acre for the year.

The fertilizer used on plats 1, 3, and 5 was applied at the rate of 65.5 pounds of nitrogen, 59.5 pounds of phosphoric acid, and 100 pounds of potash per acre. The nitrogen was furnished by nitrate of soda, which was given in four applications, and the phosphoric acid and potash in two applications. Plats 7 and 8 were treated with a single application of barnyard manure at the rate of approximately 15 tons per

[12] Guam Agr. Expt. Sta. Rpt. 1916, pp. 21, 22.

acre. The effect of each commercial fertilizer application was apparent within five days. The grass on the fertilized plats grew much more quickly and had a larger percentage of stems than that on the unfertilized plats.

TABLE 5.— *Yields of green forage from treated and untreated plats.*

| Plat No. | Number of cuttings. | Treatment. | Acre yield of green forage. |
|---|---|---|---|
| | | | *Pounds.* |
| 1 | 5 | Complete fertilizer | 55,348 |
| 2 | 4 | No treatment | 28,483 |
| 3 | 3 | Plowed plus complete fertilizer | 24,426 |
| 4 | 3 | Plowed only | 19,487 |
| 5 | 5 | Complete fertilizer | 39,291 |
| 6 | 3 | No treatment | 15,887 |
| 7 | 4 | Plowed plus barnyard manure | 29,344 |
| 8 | 6 | Barnyard manure | 65,604 |

The plowing of plats 3, 4, and 7 was done on August 4, 5, and 6. On plats 3 and 4 no cutting was made until December; while on plat 7 a cutting was made in September. The barnyard manure, therefore, brought about a much quicker recovery of the grass than did the commercial fertilizers.

The decidedly beneficial effect of the plowing alone was shown in the April cutting, when plat 4 yielded at the rate of 8,913 pounds of green forage per acre, while plat 3 adjoining, although fertilized and plowed, gave only 10,869 pounds per acre. Counts made in May showed that the stand on plat 4 had been slightly more than doubled, as compared with unplowed and unfertilized plat 6. The commercial fertilizers have brought about a slightly increased stand.

Table 6 is a summary of the results of the work done in 1916, 1917, and 1918. The field notes, made December 12, 1917, show the general condition of the plats during the test. No fertilizer was applied during the third year, nor were the plats plowed or manured after the first year.

TABLE 6.—*Summary of three years' work on renovating Para grass.*

| Plat No. | Area. | Number of cuttings. | Total fertilizer applied per acre in two years. | Acre yield of green forage. | Remarks. |
|---|---|---|---|---|---|
| | *Acres.* | | | *Tons.* | |
| 1 | 0.41 | 14 | Nitrate of soda, 804.2 pounds; acid phosphate, 951.2 pounds; potassium sulphate, 460.9 pounds. | 89.00 | Excellent stand; heavy growth of dark green grass 40 inches high. |
| 2 | .41 | 14 | Check | 43.05 | Not an extra good stand; about 32 inches high. Considerable amount of other grass and weeds present. |
| 3 | .23 | 9 | Nitrate of soda, 704.3 pounds; acid phosphate, 739.1 pounds; potassium sulphate, 347.6 pounds (plowed). | 42.58 | Heavy rank growth; apparently as good as plat 1; no weeds. |
| 4 | .23 | 9 | Plowed only | 41.94 | Fairly good growth; about 36 inches high; no weeds. |
| 5 | .24 | 12 | Nitrate of soda, 538.0 pounds; acid phosphate, 554.2 pounds; potassium sulphate, 260.8 pounds. | 48.69 | Fair stand, but a poor growth; about 28 inches high; weeds. |
| 6 | .24 | 11 | Check | 29.89 | Not as good as plat 5; about 25 inches high. |
| 7 | .21 | 13 | Plowed; barnyard manure, 30,000 pounds. | 71.93 | Rank growth; about 32 inches high; some weeds. |
| 8 | .21 | 16 | Barnyard manure, 30,000 pounds | 91.58 | Good stand; about 38 inches high. No weeds. A lighter green color than that of some other plats. |

It should be noted that while the field was the most even that could be secured for experimental work, certain small differences were observed in the soil and drainage conditions. (Pl. III, fig. 1.) Plats 1 and 2 were comparable, plats 3, 4, 5, and 6 were very nearly alike, and plats 7 and 8 were comparable with each other. From these results it is apparent that manure, applied to the land which received no cultivation, has had the most beneficial effects in renovating Para grass. Plat 1, which received a heavy application of a complete commercial fertilizer, gave the second highest yield, followed by plat 7, which had been both plowed and manured. The lowest yield was from plat 6, a check plat which had received no treatment.

The beneficial results of plowing the plats are not so apparent in the yields as they are in the grade of forage produced. The plowed plats produced a crop entirely free from other grasses or weeds and, at the same time, were easier to cut because the ground was much smoother than that of the other plats.

*Comparison of fertilizer elements used in test.*—The amount of the fertilizer elements applied to the different plats is shown in Table 7. Common barnyard manure was used, the analysis given being an average employed in the States.[13] The analyses of the commercial fertilizer represents the minimum figures furnished by the company from whom the fertilizers were purchased.

TABLE 7.—*Comparison of fertilizer elements used on Para grass.*

| Plat No. | Treatment per acre. | Amount of fertilizer element applied per acre. | | | | | | Yield of green forage per acre (July 1, 1915, to Feb. 21, 1919). |
|---|---|---|---|---|---|---|---|---|
| | | Nitrogen (N). | | Phosphorus ($P_2O_5$). | | Potash ($K_2O$). | | |
| | | *Pounds.* | *Per cent.* | *Pounds.* | *Per cent.* | *Pounds.* | *Per cent.* | *Tons.* |
| 1 | Commercial fertilizer | 105.6 | 15.0 | 133.1 | 14.0 | 193.0 | 42.0 | 105.26 |
| 2 | No treatment | | | | | | | 52.21 |
| 3 | Plowed plus commercial fertilizer | 52.7 | 15.0 | 58.0 | 14.0 | 81.9 | 42.0 | 55.02 |
| 4 | Plowed only | | | | | | | 49.61 |
| 5 | Commercial fertilizer | 80.7 | 15.0 | 77.6 | 14.0 | 109.5 | 42.0 | 55.65 |
| 6 | No treatment | | | | | | | 40.46 |
| 7 | Plowed plus barnyard manure | 150.0 | .5 | 45.0 | .15 | 120.0 | .4 | 78.37 |
| 8 | Barnyard manure only | 150.0 | .5 | 45.0 | .15 | 120.0 | .4 | 122.23 |

The yields given are for the period extending from July 1, 1915, to February 21, 1919. It would seem that the largest yields were obtained where organic matter and large amounts of nitrogen were added to the soil. The soil upon which the tests were made is classed as a clay and contains 46.2 per cent clay and 34.8 per cent silt. The chemical analysis of a composite soil sample showed the following

[13] Hopkins, C. G. Soil Fertility and Permanent Agriculture, Boston, 1910, p. 157.

results: Silica ($SiO_2$), 44.57 per cent; titanium ($TiO_2$), 0.92 per cent; iron ($Fe_2O_3$), 13.96 per cent; alumina ($Al_2O_3$), 21.50 per cent; manganese (MnO), 0.29 per cent; lime (CaO), 1.22 per cent; magnesia (MgO), 2.20 per cent; potash ($K_2O$), 0.45 per cent; soda ($Na_2O$), 0.25 per cent; phosphoric acid ($P_2O_5$), 0.06 per cent; sulphuric acid ($SO_3$), 0.20 per cent; nitrogen (N), 0.29 per cent; and loss on ignition, 14.09 per cent.

*Residual effect of treatments.*—To determine the residual or lasting effects of the different treatments given Para grass in the renovation tests, records were kept of the yields beginning one year after the last application of fertilizers, and two years after plowing and manuring the plats. These yields were taken from July 3, 1917, when the first cutting was made on plat 6, to February 21, 1919, when the last cutting was made on plat 7, extending over a period of approximately 18 months for each plat. Table 8 is a summary of these data.

TABLE 8.—*Yields of Para grass and residual effects of fertilizers.*

| Plat No. | Number of cuttings. | Treatment per plat. | Yield of green forage per acre, July 3, 1917, to July 21, 1919. |
|---|---|---|---|
| | | | *Tons.* |
| 1 | 9 | Complete fertilizer | 47.22 |
| 2 | 7 | No treatment | 24.48 |
| 3 | 5 | Plowed plus complete fertilizer | 27.44 |
| 4 | 5 | Plowed only | 28.42 |
| 5 | 5 | Complete fertilizer | 24.90 |
| 6 | 5 | No treatment | 19.71 |
| 7 | 6 | Plowed plus barnyard manure | 26.16 |
| 8 | 10 | Barnyard manure only | 56.10 |

These data show that plat 8, to which only barnyard manure had been applied, gave the most lasting effect of any of the different treatments; it produced 56.10 tons of green forage in the 18 months. Plat 1, which had formerly been treated with a heavy application of a complete commercial fertilizer, was next, producing a yield of of 47.22 tons of green forage. Plats 3 and 4, which are very comparable with 5 and 6, showed that the effect of the plowing was also still evident in the yields.

*Effect of velvet beans when planted with Para grass.*—In an established area of 0.6 of an acre of Para grass that had been cut regularly for at least two years previously, one half was planted to velvet beans and the other was left as a check (Pl. III, fig. 2). After the Para grass had been cut the beans were planted in rows 3 or 4 feet apart each way. No preparation was given the soil, and the beans were dropped in holes which were made with a sharp-pointed stick, and covered with dirt which was slightly packed down. A poor

stand was obtained from the first crop because the lower end of the plats was wet and the seed rotted. Table 9 shows the results from two crops which were cut within six months from the time of the first planting.

TABLE 9.—*Results of comparative test of velvet beans planted with Para grass.*

| Number of crop. | Yield of green forage per acre. | |
|---|---|---|
| | Velvet bean and Para plat. | Check plat. |
| | *Tons.* | *Tons.* |
| 1 | 2.16 | 1.26 |
| 2 | 5.36 | 1.34 |

The yield was considerably higher from the second crop where velvet beans were planted and where a good stand was obtained than from the first one. The yield of the second crop showed an increase over that of the first, and the quality of the forage was much better, as the nitrogenous food was given the animals along with the roughage portion of the ration.

*Yields from other places.*—Table 10 is a brief summary of the results that have been reported from other tropical and semitropical localities.

TABLE 10.—*Comparison of yields of Para grass as reported from various places.*

| Location. | Source of information. | Remarks. |
|---|---|---|
| Hawaii | Experiment station correspondence | 25 to 50 tons per acre. |
| Louisiana | do | Makes very good growth. |
| Porto Rico | do | Principal forage and very productive. |
| Florida | do | 1 to 4 tons per acre.[1] |
| Mississippi | S. M. Tracy, "Para Grass" (leaflet), U. S. Dept. Agr., Bur. Plant Indus., Jan., 1909. | 3 to 15 tons per acre. |
| Florida | S. M. Tracy, "Forage Crops for the Cotton Region," U. S. Dept. Agr., Farmers' Bul. 509 (1916), p. 11. | 3 to 4 cuttings annually. |
| Do | S. M. Tracy, "Some Important Grasses and Forage Plants for the Gulf Coast Region," U. S. Dept. Agr., Farmers' Bul. 300 (1907), p. 15. | 8 to 10 tons per acre. |
| Do | Florida Expt. Sta. Rpt. 1912, p. XXXV | 2,760 pounds per acre. |
| Texas | S. M. Tracy, "Forage Crops for the Cotton Region," U. S. Dept. Agr., Farmers' Bul. 509 (1916), p. 11. | 12 tons per acre. |
| Hawaii | Hawaii Sta. Bul. 36 (1915), p. 23 | 31 tons per acre. |
| Philippines | Philippine Agr. Rev., 4 (1911), p. 404 | Produces large amount of pasturage. |
| Australia | E. Breakwell, "Pasture Grasses," Dept. Agr., New South Wales, Farmers' Bul. 96, p. 77. | Endures an unlimited amount of trampling and grazing. |
| Fiji | Agricultural Gazette, New South Wales, December, 1918, p. 840. | 31 tons per acre in 4 cuttings within 9 months. |
| Ceylon | Agricultural Gazette, New South Wales, December, 1918, p. 841. | 2 cuttings at intervals of 87 days; 12 tons green fodder per acre. |
| British Guiana | do | 5 cuttings in 1 year yielded 41½ tons per acre.[2] |

[1] Evidently means at each cutting.

[2] This is said to be probably the highest yield recorded from this grass and was from an old, established plat.

The table shows that the yields vary from 1 or 2 tons to as high as 30 or 40 or more tons of green forage per acre. It is rather remarkable, however, that almost identical results have been obtained in the strictly tropical countries having similar climatic conditions. In Guam the highest recorded yield for an extended period covering 42 months is an average of 34.92 tons of forage per annum.

### FEEDING VALUE.

*Palatability.*—In all cases Para grass has proved very palatable to all classes of live stock. It is tender, sweet, and nutritious when young; later it becomes dry and woody. If the grass is not too old when cut, animals will eat it with some relish even after it has dried. In this stage, however, there is considerable waste. Several new shoots put out at the first joint where it is eaten off in the field. In this way new growth continually starts and furnishes succulent grazing.

In many instances Para grass has been eaten by sick animals that refused all other forage except breadfruit, of which cattle and horses are very fond. Cattle on range pastures at Cotot have shown a decided preference for Para grass, daily leaving good native pasture, wooded range, and Paspalum grass for the Para grass. They continued to graze on it until it was very closely eaten or the dry weather had caused a decrease in its growth. That cattle do not have to acquire a liking for Para grass is shown by the fact that live stock readily eat it when they have just been imported from the States, where this grass does not grow. When planted in the same pasture in which other crops are grown, generally the Para grass is eaten first.

In a field containing velvet beans and new-growth Para grass the hogs ate the grass in preference to the legume. Experimental data have shown the necessity of establishing suitable pastures for profitable hog production in Guam. The cost of imported feeds prohibits their use for anything except possibly the finishing of hogs for slaughter. Very satisfactory results have been obtained where Para was used as a pasture crop for hogs. It is grown in several of the swine pastures at this station, and is eaten by hogs of all ages. Cattle and goats, as well as hogs, have been pastured on Para grass with equally good results. Experiments have shown the Para grass to be far superior to the native pastures, and preferred by the cattle to Paspalum. Animals pastured on Para grass kept in good condition and made consistent gains, while cattle that were fed on native grasses lost weight. These tests show that this grass is one of the most palatable, if not the most palatable, of the forage crops on the island.

*Analyses.*—hemical analyses of Para grass from this station and from various other sources, showing the percentages of water, protein, fat, carbohydrates, and ash, are given in Table 11.

TABLE 11.—*Some analyses of Para grass.*

| Authority. | Composition. | | | | | |
|---|---|---|---|---|---|---|
| | | | | Carbohydrates. | | |
| | Water. | Protein. | Fat. | Crude fiber. | Nitrogen-free extract. | Ash. |
| Fresh green material: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Henry-Morrison[1] | 72.80 | 1.70 | 0.50 | 9.20 | 13.40 | 2.40 |
| Hawaii Agricultural Experiment Station[2] | 72.18 | 3.46 | 1.33 | 7.65 | 11.04 | 4.34 |
| Do[3] | 74.60 | 2.28 | .29 | 9.10 | 10.92 | 2.81 |
| Air-dry material: | | | | | | |
| Guam Agricultural Experiment Station[4] | 5.90 | 13.50 | 1.20 | 34.70 | 35.80 | 8.90 |
| Do[4] | 3.90 | 19.10 | 1.80 | 35.80 | 29.97 | 12.33 |
| Henry-Morrison[1] | 9.80 | 4.60 | .90 | 33.60 | 44.50 | 6.60 |
| Texas Agricultural Experiment Station[5] | 8.36 | 3.44 | .91 | 33.80 | 46.74 | 7.10 |
| Florida Agricultural Experiment Station[6] | 12.57 | 7.21 | .80 | 33.08 | 40.66 | 5.68 |
| Dry-matter basis: | | | | | | |
| Hawaii Agricultural Experiment Station[7] | ..... | 9.10 | 1.11 | 35.96 | 42.92 | 11.06 |

[1] Feeds and Feeding. The Henry-Morrison Co., Wisconsin, pp. 639 and 643.
[2] Hawaii Agr. Expt. Sta. Rpt. 1907, p. 63.
[3] Hawaii Agr. Expt. Sta. Bul. 13 (1906), p. 8.
[4] Analyzed by the Bureau of Chemistry, U. S. Department of Agriculture.
[5] Texas Agr. Expt. Sta. Bul. 147 (1912), p. 7.
[6] Florida Agr. Expt. Sta. Rpt. 1909, p. XIX.
[7] Hawaii Agr. Expt. Sta. Bul. 36 (1915), p. 11.

In order to compare the feeding value of Para grass with other forage crops and feeding stuffs, Table 12 is given.

TABLE 12.—*Composition of various forage crops.*

| Kind of forage. | Proximate constituents. | | | | | |
|---|---|---|---|---|---|---|
| | Water. | Protein. | Fat. | Nitrogen-free extract. | Crude fiber. | Ash. |
| Air-dried material: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Para[1] | 4.90 | 16.30 | 1.50 | 32.88 | 33.80 | 10.61 |
| Paspalum[1] | 4.95 | 14.19 | 2.10 | 35.84 | 33.35 | 9.57 |
| Native grass[1] | 4.70 | 12.19 | 1.20 | 40.22 | 30.60 | 11.09 |
| Copra meal[1] | 6.69 | 18.94 | 15.14 | 40.88 | 12.33 | 6.02 |
| Velvet bean[2] | 7.20 | 16.40 | 3.10 | 38.40 | 27.50 | 7.40 |
| Dry-matter basis: | | | | | | |
| Para[3] | ..... | 9.10 | 1.11 | 42.92 | 35.96 | 11.06 |
| Paspalum[3] | ..... | 11.23 | 2.44 | 42.21 | 34.48 | 9.55 |
| Guinea grass[3] | ..... | 5.52 | .87 | 54.59 | 28.17 | 10.89 |
| Sudan grass[3] | ..... | 8.44 | 1.89 | 43.06 | 36.99 | 9.62 |
| Bermuda grass[3] | ..... | 6.86 | .58 | 59.84 | 22.93 | 9.83 |
| Johnson grass[3] | ..... | 8.01 | 2.33 | 51.10 | 31.70 | 6.80 |
| *Desmodium triflorum*[3] | ..... | 14.42 | 4.07 | 39.90 | 33.40 | 7.92 |
| Alfalfa[3] | ..... | 25.26 | 1.76 | 32.25 | 28.85 | 11.23 |
| Cowpea[4] | ..... | 21.99 | 1.33 | 31.20 | 34.15 | ..... |
| Pigeon pea[4] | ..... | 23.69 | 5.51 | 26.26 | 35.73 | ..... |
| Jack bean[4] | ..... | 22.44 | 2.08 | 36.42 | 27.42 | ..... |
| Cassava root[3] | ..... | 3.79 | 8.21 | 72.02 | 10.93 | 4.07 |

[1] Guam Agricultural Experiment Station average of analyses by Bureau of Chemistry, U. S. Department of Agriculture.
[2] Henry & Morrison, Feeds and Feeding, 1916, p. 641.
[3] Hawaii Agr. Expt. Sta. Bul. 36 (1915), p. 11.
[4] Hawaii Agr. Expt. Sta. Rpt. 1908, p. 59.

The analyses of the Para and Paspalum grasses from Guam compare favorably with those of the grasses from other places. These grasses have a high content of protein and fat, two of the most

important compounds for a high feeding value. Doubtless this accounts for the ease with which live stock pastured on these grasses is kept in good condition.

*Comparative feeding tests with Para grass for horses.*—Feeds can not be compared by chemical analyses entirely; their value depends also on palatability and digestibility. No percentages of digestibility have been worked out by feeding experiments carried on in Guam, but preliminary comparative tests were conducted to determine the value of Para grass compared with other feeds.

Feeding tests at the station indicate that Para grass can be satisfactorily utilized for the entire forage portion of at least the light work ration of horses. It has been found that horses will maintain their normal weight when they are given a daily forage ration of 40 to 60 pounds of green Para grass in addition to a light grain ration.

During the year 1916–17 a feeding test was conducted with several horses either used at light work or given daily exercise during the period. Imported alfalfa hay was used as a check with which to compare Para grass. Alfalfa was fed at the rate of 10 to 15 pounds, and Para at the rate of 40 to 60 pounds daily. The grain ration consisted of 5 pounds of oats daily. The results of the test are summarized as follows:[14] "Throughout the experiment the weights of the animals were maintained or only slightly increased by the Para ration, while the alfalfa gave a considerable increase of weight in each instance. The total of results would seem to indicate that Para grass can be satisfactorily utilized as the entire forage portion of the maintenance or light work ration of horses. With respect to gains in weight, results were much in favor of the alfalfa hay. The Para grass, however, constituted much the cheaper feed," and the more practical of the two under Guam conditions.

*Comparative feeding tests with Para and native grasses for cattle.*—All tests with native and Para grass showed the latter to be much the better of the two. A comparative test was begun on February 14, 1917, and concluded August 15 at the Cotot stock farm. Seven native cows of about the same age and one grade heifer, No. 38, were used in the test. Four of the animals were pastured on a field of Para grass consisting of about 5 acres. The other four were on a native pasture consisting approximately of 95 acres of woodland and 35 acres of upland grass, which was largely made up of the awn grass, "inifuk" (*Andropogon aciculatus*). Although the test was conducted in the ordinarily dry part of the year, frequent rains occurred during the time it was under observation. These rains made the pasture better, especially the native areas, than would have been the case under the more pronounced dry season.

[14] Guam Agr. Expt. Sta. Rpt. 1917, p. 8.

The cattle placed on the Para pasture had formerly been grazing on native pasture; and the four head placed on native pasture had formerly been on Para pasture. Table 13 is a summary of the results obtained from the test. Each animal, when removed from native pasture and placed on Para pasture, steadily gained weight, and made an average gain of 164 pounds, or nearly a pound a day for the 182 days during which the test was conducted. On the other hand, the cattle taken from the Para and placed on the native pasture lost an average of 122 pounds, or approximately two-thirds of a pound a day.

TABLE 13.—*Comparative grazing values of Para grass and native pastures.*

| Lot 1, Para pasture. | | | | | Lot 2, native pasture. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cow No. | Weight. | | | Gain in weight. | Cow No. | Weight. | | | Loss in weight. |
| | Feb. 14. | June 29. | Aug. 15. | | | Feb. 14. | June 29. | Aug. 15. | |
| | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 20..... | 432 | 520 | 583 | 151 | 12..... | 569 | 437 | 424 | 145 |
| 30..... | 497 | 551 | 593 | 96 | 17..... | 510 | 366 | 330 | 180 |
| 31..... | 359 | 485 | 578 | 219 | 18..... | 624 | 519 | 495 | 129 |
| 38..... | 324 | 462 | 514 | 190 | 26..... | 620 | 579 | 585 | 35 |

This test showed the Para grass to be far superior to the native grass. However, it should be noted that cows Nos. 31 and 38 were in very poor flesh when turned on the Para; and also that the native pasture in this test was considerably above the average on the island. It is an actual fact that each year a number of cattle pastured on the scant vegetation supplied by the native ranges become thin and die. No cases are known where this has happened when the herd was pastured on one of the introduced pastures of Para grass or Paspalum grass.

*Comparative feeding tests with Para and native grasses for swine.*—Results with Para grass show that it is well adapted as a pasture grass for hogs of all ages. Para grass probably does not equal certain leguminous crops for this purpose, yet mature animals have kept in good condition when given it with only a slight supplementary ration of other feeds. In a number of tests where Para was used as a pasture grass, hogs, especially brood sows, were maintained with very satisfactory results.

During 1917, grade Berkshire pigs 3 months old were used in a test to compare the pasture value of native and Para grasses. Lot 1 was placed on one-half acre of good native pasture, while lot 2 was placed on one-fourth acre of Para grass of two years' standing. The results of the test are shown in Table 14.

FIG. 1.—STATION PLATS OF PARA GRASS.

FIG. 2.—PARA GRASS AND VELVET BEANS.

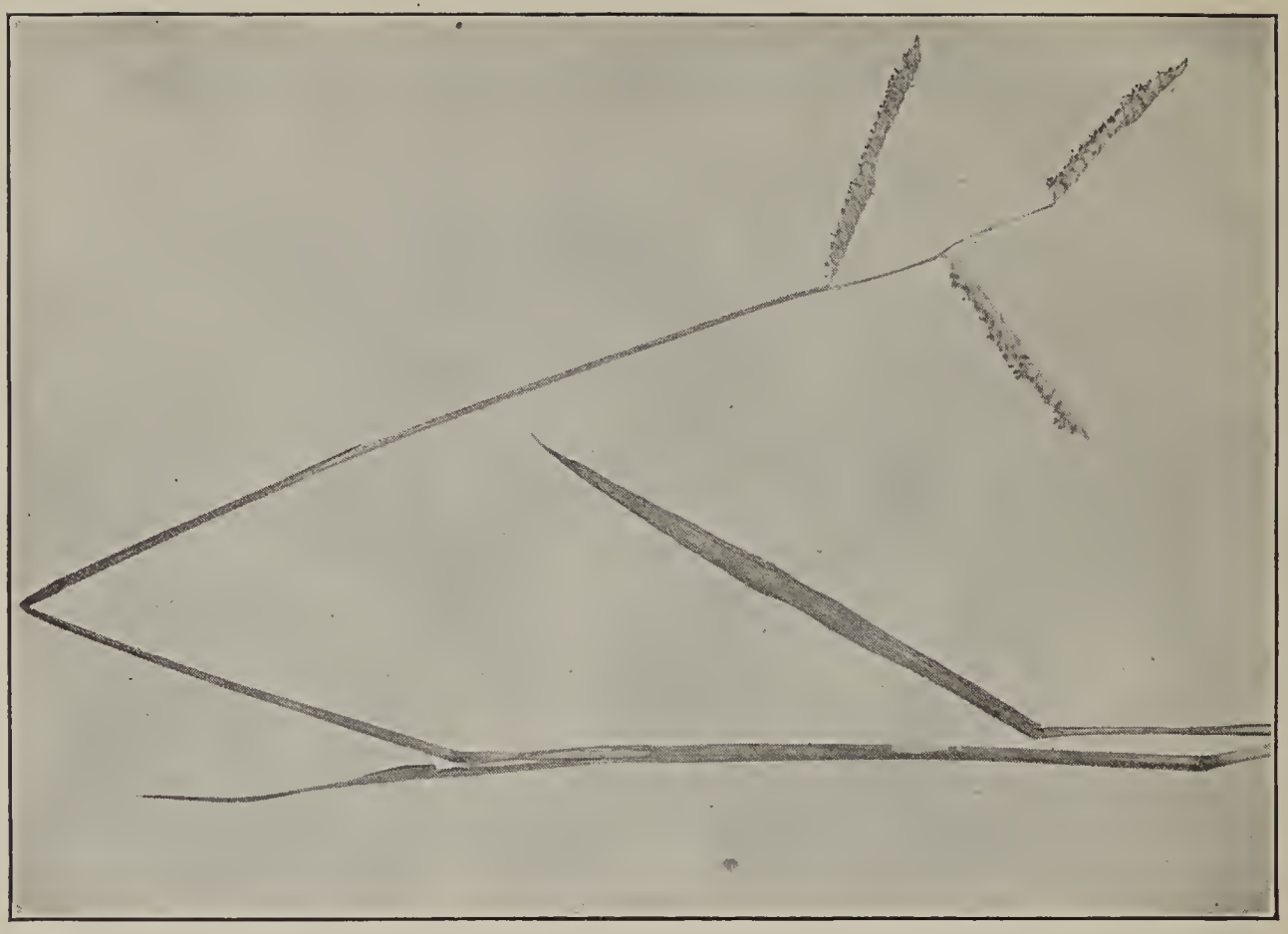

FIG. 2.—PASPALUM DILATATUM FLOWERING STEM.

FIG. 1.—PASPALUM DILATATUM SHOWING TUFTED HABIT.

TABLE 14.—*Comparative value of Para grass and native pastures.*

| Lot 1, native pasture. | | | | Lot 2, Para pasture. | | | |
|---|---|---|---|---|---|---|---|
| Pig No. | Weight. | | Gain in weight. | Pig No. | Weight. | | Gain in weight. |
| | Jan. 16. | Apr. 16. | | | Jan. 16. | Apr. 16. | |
| | *Pounds.* | *Pounds.* | *Pounds.* | | *Pounds.* | *Pounds.* | *Pounds.* |
| 120 | 18.5 | 45.0 | 26.5 | 123 | 25.5 | 75.0 | 49.5 |
| 122 | 32.5 | 77.5 | 45.0 | 125 | 19.5 | 65.5 | 46.0 |
| 124 | 21.0 | 49.0 | 28.0 | 127 | 21.0 | 55.5 | 34.5 |
| 128 | 17.0 | 38.0 | 21.0 | 138 | 27.0 | 66.0 | 39.0 |
| 134 | 17.0 | 39.5 | 22.5 | 139 | 19.0 | 54.5 | 35.5 |
| 141 | 18.0 | 51.0 | 33.0 | 140 | 14.0 | 55.5 | 41.5 |

It will be noted that the average weight of the pigs at the beginning of the experiment was 20.6 pounds for those on native pasture and 21 pounds for those on Para grass. At the end of the 90-day period those on native pasture averaged 50 pounds, or a gain of 29.4 pounds, while those on Para averaged 62 pounds, or a gain of 41 pounds. This gave the pigs having access to the Para pasture an average gain of 11.7 pounds over the lot running on native pasture. As this experiment was conducted during the dry season on an old growth of Para grass, the results probably do not show as favorable returns for that grass as would be the case on new growth and with more moisture.

*Para grass as a feed for goats.*—No tests were carried on to compare the value of Para grass with other forage as a feed for goats, but it has given very satisfactory results at this station. A large number of goats that have never received any forage other than Para grass have kept in good condition. Observations would seem to indicate that it is a very desirable forage.

### CARRYING CAPACITY.

It is important that Para grass be well established before it is pastured. Close pasturing, especially on dry soils, kills the grass. In one of the station pastures a small area, containing about three-fourths of an acre of Para grass, supported two head of young cattle for nearly 10 months. The stand was badly damaged and such continuous heavy pasturing is not recommended. During the dry season of 1919 an area of less than 2 acres supported a number of mature cattle for several months when very little other forage was to be had. The stand was also damaged in this case, but after the rains started it quickly recovered. This fully demonstrated the superior ability of the Para grass over the native grasses to furnish a large amount of feed.

At Cotot on an area of about 4 acres of Paspalum and 10 acres of Para grass, 35 head of cattle at all times, and even a greater number

at intervals, were pastured from February 20 to July 1, 1919. The cattle were very thin when placed on the pasture, but were in good condition when removed. The stand was not injured in any way, but the Para showed the effects of the heavy pasturing before the cattle were removed. However, after the field was rested for six weeks a heavy growth of grass nearly 3 feet high was available and the cattle were again allowed to graze upon it. Results obtained at the station and at Cotot showed that the carrying capacity of Para grass, given reasonable care, was easily one animal unit [15] to an acre of grass.

Results obtained in other countries may be of interest in this respect, and a limited number of instances are therefore given in the following paragraphs.

In Mexico [16] "it is estimated that 2 acres of good Para grass, if cut and fed, will feed three head of stock the year round; in pasture 4 acres will fatten four head."

One field [17] of 10 acres in southern Texas gave grazing for 15 cows from May to November, and at the close of the season the grass was fully 2 feet tall and appeared to be growing faster than it was eaten, though the field had not been irrigated during the preceding 18 months. A grower in southern Mississippi reports equally good results from a planting made on low, rich land and very poor results when planted on dry clay.

Unlike [18] *Panicum maximum*, Para grass makes sweet and nutritious hay, and it will endure an unlimited amount of trampling and grazing.

A grower [19] in central Florida states that his field of Para grass gives good grazing for 6 head of cattle per acre at least 8 months each year. Another grower, in southern Florida, who has used a few acres of it for pasture a number of years, increased his planting to 100 acres last year, and others in the same section are making similar plantings.

J. B. Thompson of the Florida station, and formerly in charge of the Guam station, says in writing of Para grass in Florida: "On good ground, I am told, that it will carry two to three head of cattle per acre of pasture for 8 to 12 months of the year."

### RESTING PARA GRASS.

Para grass will stand heavy pasturing for a considerable length of time, but it is almost imperative to rest it during certain intervals of the year to prevent the stand becoming depleted. To do this one of two methods should be employed. The first is to plant an area large enough to permit pasture rotation as this allows one field to rest and produce new growth while another field is furnishing pasture grass. The second is to plant cowpeas and kafir corn to supplement the pastures during the dry season if they are being closely grazed. These two crops grow well with very little moisture and furnish feed at the time of the year when the grass is as its worst.

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[15] An animal unit may consist of 1 mature horse or cow, 2 colts or calves, 5 head of hogs, 10 pigs, or 100 chickens.

[16] H. H. Smith and F. A. G. Pape. Coconuts: The Consols of the East, p. 155.

[17] U. S. Dept. Agr., Farmers' Bul. 509 (1912), p. 11.

[18] Dept. of Agr., New South Wales, Farmers' Bul. 96 (1915), p. 77.

[19] U. S. Dept. of Agr., Farmers' Bul. 300 (1907), p. 15.

### THICKENING THE STAND.

If a stand of Para grass becomes thin from overstocking, it can easily be thickened by the use of barnyard manure containing the residues from Para grass fed to stock. This should be carefully spread over the thin spots at the beginning of the rainy season. Very good results have been obtained with applications of about 15 tons per acre. Para grass that appears dry and dead often strikes root at the nodes and grows again. In case barnyard manure is not available, cuttings of Para may be scattered over the thin area after the weeds have been removed and the ground has been properly prepared. If the stand is not too severley depleted, it may be renovated by one of the means given on page 16 under the heading "Yields."

### SPREADING HABIT.

It is feared by some that Para grass will become a pest on account of its creeping root stems and habit of rapidly spreading. This has not been found to be the case at this station where cultivated crops were grown in proximity to it. During the rainy season Para grass is sometimes troublesome in cultivated fields, but since it has a shallow root system and creeping stems, which grow on the surface of the ground, it can be removed very readily. No doubt the grass would be rather aggressive on ground that is low and wet throughout the year.

Other cultivated crops are now growing at this station on land that was formerly occupied by Para grass. During the first year or so the newly sprouting roots of the grass must be removed by hand. This can very easily be done. It has been found that Para grass can be killed by extra heavy grazing, especially during the dry season, or by shallow plowing at times of continued drought. If the prostrate runners are removed by hand from the fields where the scattering plants occur the field will soon be rid of any trace of the grass. The benefits derived from the use of the grass are so great that no one objects to the small amount of labor required to keep it from encroaching on cultivated fields.

### SEED PRODUCTION.

Seed is produced during or near the latter part of the rainy season, especially in the older plantings that have not been cut for some time. The seed heads are produced in quantity, but the seed does not fully develop. Only a small portion of the seeds ever mature sufficiently to germinate. In a germination test of clean heavy seed planted in the plant house, about 25 per cent of them was found to be viable. The seed is rather difficult to harvest, as it matures unevenly in the heads, which likewise ripen unevenly in the field. It has been found best to harvest by stripping the ripe seeds from the panicles by hand

when only small quantities of seed are desired. Imported seed has never given satisfactory results. As it is more practicable to propagate Para by stem cuttings, the practice of sowing seed is not recommended.

### INSECTS AFFECTING PARA GRASS.

Up to the present time Para grass has been conspicuously free from injurious insects. "The caterpillar [20] of a pyralid moth commonly rolls the leaves. It is parasitized by an Apanteles. A psyllid is also found on the leaves and a locustid occasionally gnaws the stems, but does little apparent damage."

During the last two years the rice bug of India (*Leptocorisa varicornis*) has been found infesting the Para fields, where it probably feeds upon the succulent stems during the periods between rice crops and the next breeding season. However, it apparently does little damage to the Para.

## PASPALUM GRASS (PASPALUM DILATATUM).

### BOTANY.

Paspalum grass, known to botanists as *Paspalum dilatatum*, belongs to the same tribe, Paniceæ, as Para grass, but to a separate genus. Para grass (*Panicum barbinode*) is one of the Panic grasses and belongs to the genus Panicum, but Paspalum (*Paspalum dilatatum*) belongs to the genus Paspalum. Each genus contains a large number of species, most of which are found in the Tropics or semitropics. The Panicum group probably contains more than 400 species and the Paspalum group fully 200 species. In Guam three recognized and identified Paspalums are grown, two of which (*P. conjugatum* and *P. scrobiculatum*) are growing wild, but the other (*P. dilatatum*) has been introduced and is a cultivated grass.

Paspalum grass (*Paspalum dilatatum*) is commonly known as large water grass, but has also been called Dallis grass, golden crown grass, hairy-flowered Paspalum, "breed Zaad grass," and Australian water grass. It is a native of South America, coming from both Brazil and Argentina, and is frequently spoken of as native of the Gulf States. At present it is distributed throughout the Tropics, and extends well up into the frost regions where it remains dormant during the winter. It has been found to be one of the best pasture grasses in New South Wales, Australia, the Union of South Africa, the Hawaiian Islands, some parts of the southern United States, the Fiji Islands, many of the other South Sea Islands, South America, and Guam of the Marianas Islands.

Paspalum grass (*Paspalum dilatatum*) is a smooth perennial grass that produces many succulent basal leaves (Pl. IV, fig. 1). The root system is strong, deep, and fibrous. Ordinarily the grass grows in

[20] Guam Agr. Expt. Sta. Rpt. 1911, p. 29.

tufts, tussacks, clumps, or bunches, but these undesirable features are overcome by thick planting and by keeping the grass pastured down. The leaves grow from 18 to 30 inches in height, and the seed stems are from 12 to 18 inches longer. (Pl. IV, fig. 2.) The stems are bare of leaves, except for a short blade at each node. They are weak, spindling, few to a clump, and do not stand up straight. Seed is produced during the rainy season from July until about November. The spikelets are plano-convex, hairy, and subsessile in spike-like racemes. The seeds are slightly elliptical in outline, flattened on one side, and convex on the other. The plant is adapted to withstand extremes of drought and rainfall.

### INTRODUCTION INTO GUAM.

The first introduction of Paspalum grass into Guam was in 1909, when it was brought in by the Guam Agricultural Experiment Station, the seed having been obtained from the Office of Forage Crop Investigations, Bureau of Plant Industry, U. S. Department of Agriculture. The introduction of this grass, together with Para grass, has been one of the most important developments of the forage investigations at the Guam station. Since the time of its introduction, it has been grown in steadily increasing areas each year.

### ADAPTATION TO GUAM.

Paspalum grass (*Paspalum dilatatum*) has been grown in Guam with excellent results during the last 10 years throughout the wet and dry seasons. Its ability to withstand extremes of drought and rainfall makes it a very valuable grass for Guam. On account of its strong and deep root system it is able to withstand droughts so severe as to kill the ordinary grasses. While Paspalum is primarily a pasture grass, it is one that seems suited to all soil conditions. It thrives well on poorly drained soil during long periods of heavy rainfall; it does well without irrigation during the dry season when native pasturage is scarce; and it has been planted with satisfactory results on exceptionally heavy clays, on medium clay soils, on the sandy beaches, and on hillsides where outcropping rock and cascajo[21] formed the principal part of the surface. There is little or no doubt that a good stand can be obtained on all but the poorest or undrained soils if the roots are placed close together. In this particular it should be noted that on the undrained soils Para grass gives the greatest yields both for pasture and for soiling purposes. However, it has been found that on the poorer soils extreme care is necessary, as too heavy pasturing destroys the stand, but even on the hillsides, and during severe droughts when other grasses are practically worthless, Paspalum will make considerable growth. From comparative tests it has been found that Paspalum grows better on higher and poorer land, withstands heavier

[21] A formation or deposit made up largely of clay and disintegrated coral.

pasturing, and survives a severe drought much better than Para grass. Another feature about this grass is that it readily withstands the trampling of stock during wet weather. In fact trampling, when the soil is wet and muddy, has a tendency to spread the grass and keep down the tuft or bunching habit.

Since the soil in Guam is usually soaked by continual rains during a season covering four months and for the same length of time is subjected to an extremely dry season during which it cracks open, especially on the lower land, one can readily understand why Paspalum, with its strong, deep root system and drought-resistant properties, is welcomed as a wonderful pasture crop. No other tested pasture grass has stood the climatic conditions or been so well liked by the live stock.

### USES.

Paspalum grass is used largely as a pasture grass and as such has a wide range of usefulness. (Pl. V, fig. 1.) As it readily grows from sea level to the highest hills, except possibly on the poorest red clay uplands, it is found to offer excellent opportunities to all farmers needing good pasturage. It gives more grazing, even on the poorer, rocky soils, than the native grasses. On account of the bunched effect of Paspalum grass, which renders difficult the process of mowing, the grass is not used as a cut green forage crop to any extent. It has been tried for making hay, but it cures very slowly and has not proved so good a cut forage as Para grass.

Once Paspalum grass is well established it makes a permanent pasture. This is a great advantage in that it eliminates the necessity of annually planting forage crops and saves the expense entailed in such plantings. Moreover, it helps to keep down noxious weeds and many other undesirable plant growths. Some of the pastures of the station have been in Paspalum for 10 years and are still in excellent condition, a fact which shows that the grass is aggressive and able to maintain its own against other grasses and weeds.

Australia has had more or less trouble in finding a grass suited to her needs. That Paspalum grass has almost revolutionized the dairy industry in New South Wales is shown by the following quotation:[22]

> The history of Paspalum in New South Wales reads almost like a romance. Less than twenty years ago the towns of the North Coast were, for the most part, struggling villages, the inhabitants of which eked out an existence by dairying on buffalo, English and native grasses. * * * Since 1898 the cultivation of the grass has steadily increased, and at the present time the area under Paspalum in the coastal districts considerably exceeds that of any other grass. * * * It is also claimed by some that the cattle do not care for it and do not milk well on it, but to that the cheques of the dairymen possessing Paspalum pastures are sufficient and convincing reply.

[22] Dept. of Agr., New South Wales, Farmers' Bulletin 96 (1915), pp. 31 and 34.

That in the United States Paspalum has been found to make a good growth in the South is confirmed by the following statement:[23]

The leaves are very long and are produced in great abundance. It remains green all winter, uninjured except by the hardest of frosts. During the early spring the growth is very strong and rapid, and it bears grazing well. Stock do not appear to be very fond of it after it has attained more than a foot or 18 inches in height, but if kept pastured down they seem to relish it well. On the whole, it may be considered one of the best of grasses for suitable soils in the South.

Paspalum has been found to be a good grass under shade on clay lands in the moist regions of the extreme South. In Guam it has been planted under considerable shade from coconuts, camachile (*Pithecolobium dulce*), and breadfruit (*Artocarpus communis*) trees. While the grass apparently made a good growth under these conditions, it did not stand as heavy pasturing as where it was planted in the open.

Very favorable reports have come from Hawaii,[24] where—

under good conditions it is possible to make hay from this grass as well as to use it for soiling. However, because of its habit of growth, it is very difficult to mow with machine or scythe, but may be cut with Japanese grass blades. It is difficult to cure because of the large moisture content, and the hay seems to be much less palatable than the fresh grass. Hence this grass should be considered as a pasture grass only, and as such it heads the list * * * To sum up, water grass [Paspalum] is one of the best grasses introduced into Hawaii. It is valued (1) for its ability to grow under various conditions of soil, moisture, or elevation; (2) it is easy to establish from seed or by division of the roots; (3) for its drought resistance; (4) for its persistence—its ability to survive overstocking; (5) for its palatability and nutritive properties; and (6) for the large amount of feed it produces and because it seeds freely.

### WHERE TO PLANT.

Results obtained from soil studies and plantings show that Paspalum grass can be grown on nearly all types of soil. It has been noted, however, that the low, moist clay, loam soils produce the largest yields and furnish the greatest amount of excellent grazing for long periods during the year. Paspalum grass may be planted on almost all the soil types from the beach to the highest hills on the island. The station has plantings on all kinds of soil wherever pasture is desired, and in all cases the Paspalum grass has made good growth and has been found greatly superior to any of the native or introduced pasture grasses.

On the hillsides where formerly sword grass (*Miscanthus floridulus*), locally known as "neti," flourished in the past and produced a coarse, dry feed, Paspalum has been planted with no preparation other than that of clearing off the sword grass with a fosiño and digging small holes with a mattock in which to place the sods or the small clumps of Paspalum roots. These plantings have successfully kept down the sword grass and given a valuable pasture. This one feature

[23] U. S. Dept. Agr., Farmers' Bul. 147 (1902), p. 16.

[24] Hawaii Agr. Expt. Sta. Bul. 36 (1915), pp. 15, 16, and 17.

should make the grass a valuable one for live-stock farmers because the southern half of the island, where hundreds of such acres could be turned into good pasture lands, is one large savanna nearly covered with worthless sword grass.

At the Cotot stock farm, which is located in the center of the southern half of the island, this station has cleared large areas both on the uplands and along the watercourses and has planted them to Paspalum grass. For the past several years, experience at the farm and at this station showed the necessity of replacing the native grasses and underbrush for pasturing live stock with the proved introduced grasses. At Tumon a small area of Paspalum grass has been growing in beach sand for two years and has made a very good growth, while other grasses grow there only during the rainy season. The grass is of pale color compared with grasses grown on better soil, yet its growing there shows the extreme wide range of soils to which it may be adapted. At the Guam station a much larger area is required on upland for Paspalum grass than on the lowlands to maintain the same amount of live stock. The lowlands would therefore seem more desirable so far as carrying capacity and cost of planting are concerned. However, when cost of land is considered, the cheap savannas are favored.

Location of the pasture is of almost as much importance as the type of soil in which the grass grows. Since no animals are allowed to be kept within barrio limits, pastures should be provided as near the barrio as possible for the work animals. The general practice is to feed forage to work bulls and carabaos only at night or on days when they are not working. Under this system of feeding it is obviously necessary to maintain the best pastures possible. If the animal has to eat grass of inferior feeding value, it will not receive enough rest or food to make it strong and vigorous. Improved pastures near the barrio might be put in as a community grazing ground, and if the area is not fenced in the animals could be tethered out. Well-fenced pastures belonging to individual farms would be of even more benefit to the animals. Taken as a whole, the location is of small importance for large herds on the range. In starting Paspalum grass on these large areas, however, it is desirable that it be planted as easily and quickly as possible. The lower and more favorable locations should be chosen and fenced to prevent too early pasturing and thus facilitate the first growth. This could be used as a nursery to supply future plantings and also later to furnish a large amount of grazing from a small area of land after the grass has become well established.

New clearings from which trees and brush have been removed has a great advantage for planting over many of the other localities. In this land the weeds have not yet started, and the grass can be

quickly established without requiring cultivation or the work of keeping down other grasses or weeds until the Paspalum grass has spread over the entire area. Paspalum grass might also be planted in coconut groves that are old enough to resist damage from live stock pastured on the grass. Though this practice can not be generally recommended, the planting of Paspalum grass as an intercrop will not injure the coconut trees any more than will the growing of volunteer grass, weeds, and underbrush. At this station a plat containing several mature coconut trees was planted with Paspalum grass and, compared with surrounding trees, has continued to produce without apparent decrease in yield. Such intercropping most certainly should prove advantageous and not be any greater drain on the fertility of the soil than volunteer growth. The grass has been found in many countries to be a profitable combination with coconuts, and has made splendid grazing for cattle. The coconuts that fall to the ground are more readily found on the grass than among brush, and a clean area is a splendid preventive measure because the damage from insects is greatly lessened when trash and decaying matter are not left as breeding places. Another advantage derived from the pasturing of cattle on the grass is that the manure left on the field will return much of the fertility to the soil.

In Hawaii [25] Paspalum grass is the only grass recommended in all cases "for marshy places," "for high wet districts," "for high dry regions," "for medium elevations, moist," "for medium elevations, dry," "for lower elevations, moist," and "for lower elevations, dry." As previously mentioned, this holds equally true in Guam where every farmer has land suitable for planting Paspalum as a pasture grass.

### WHEN TO PLANT.

The time of planting Paspalum grass in Guam depends almost entirely upon local climatic conditions. In general, it is best to plant this grass at the beginning of the rainy season when there is certainty of sufficient moisture. Though Paspalum grass is a persistent grower and able to withstand long droughts, it needs to be well established and have time to develop a strong root system to withstand successfully an extended dry season or heavy grazing. Paspalum grass, like Para grass, may be planted during any time of the year if the soil is in proper condition for the development of new roots. This condition may be brought about by irrigation if sufficient rain does not fall to provide a moist seed bed. The more favorable the soil for the growth of the plant the sooner the grass will be ready for grazing Under ideal conditions for rapid growth the new plantings should not be pastured for at least four months after being transplanted.

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[25] Hawaii Agr. Expt. Sta. Bul. 36 (1915), p. 39.

On higher lands it takes longer for the grass to become established, and fully six months should elapse before live stock is allowed to pasture the field. When pasturing was allowed too soon several plantings at this station were destroyed. In some instances it is best to delay heavy pasturing several months longer.

Where seed has been planted, even more time must elapse before the grass is allowed to be pastured than where the field is established by using divisions of roots. From the foregoing remarks it will be seen that the time of planting and the time of grazing are somewhat correlated, and consequently they should be taken into consideration when the work is being planned for the time when pastures will be needed.

### HOW TO PLANT.

*Preparation of the soil.*—It is essential that careful preparation be given the soil before Paspalum is planted. As is true of other plants, a good seed bed or a well-prepared home for the many fibrous roots of this grass causes it to grow much faster and assures the farmer of a better stand than would otherwise be the case. The soil preparation, of course, depends almost entirely upon the location of the pasture. On most of the hills it is impossible to plow on account of the rocky nature of the soil. In these places all the grass, weeds, and shrubs should be removed. The root clumps can then be planted in holes made by mattocks. On soil of this kind, the grass should be weeded with fosiños two or three times to keep it clean until it is well started.

On land that is free from rocks and stumps the best method of preparation is to plow as is done for corn, or for Para grass, only the furrows should be made closer together. In newly cleared land that is full of stumps, it is probably best to use the fosiño, or mattock, to prepare the holes for sods. A stroke or two with the tool will open a hole sufficient for setting the sods. The sods should be placed close to the base of the stumps, so that as each stump rapidly decays the grass will spread over that portion. In a short time the whole area will be covered with grass. Four men make a very efficient working group. Two men using the fosiño, or mattock, can make the holes; a third man can drop the sods where wanted, followed by a man who can set them in place and firm the soil around the sods or roots.

Where it is possible to do so, the ground should be carefully prepared for the best results.

About one acre of *Paspalum dilatatum* was planted in August, 1915, on land that had been cleared but not plowed or otherwise prepared. The grass started quickly, but at the end of nine months it had made almost no headway and will probably be crowded out ultimately by native grasses and weeds. The soils at the station are generally so heavy that deep preparation is required for proper grass-root development. Another acre of grass planted on similar but well plowed and worked soil covered the land well in four months.

Careful attention after planting is necessary. Even in land well cleared and well prepared, particularly on the higher and poorer soils, weeds must be kept down after planting. All of the soils here are literally filled with weed seeds, and at least three weedings are necessary on poor soils. This is well shown on approximately one acre of grass planted with small divisions, set about 2½ feet apart, in August, 1915. About two-thirds of this planting was cleaned of weeds three times during the year, while the remainder was given no attention. At the end of nine months the grass had covered fully two-thirds of the soil where weeds were removed, while almost no growth was made on the unweeded part of the plat. Thick plantings and the use of large root divisions on lowlands largely obviate the necessity for weedings, but on carefully planted higher lands weeding is necessary.[26]

### Propagation.

There are three parts of the plant that can be used for propagation—the seeds, cuttings, and roots.

*Seed.*—Seed is sown at the rate of 12 to 20 pounds per acre on well-prepared land. Growing Paspalum grass from seed has the advantage over other methods of propagating in that it saves time in transplanting and largely helps to avoid the clumping or bunching effect of the grass. The planting of seed would probably be advisable where good seed is available at a reasonable price and the ground can be well prepared. However, seed is not available outside the San Francisco markets, to which it has been shipped from Australia, and in Guam the price and freight rates almost prohibit its purchase in any large amount. As the seed germinates slowly and some time is required for the young plants to grow, it takes longer for the grass to reach the grazing stage than when sods are planted.

*Cuttings.*—Cuttings can be made from seed stems, as these strike root at the joints, or nodes, when the plant comes in contact with the soil. The seed stems could be cut with a mower or machete and strewn over the ground; better still, they could be placed in furrows made by a plow and covered with loose soil. This is the least common of all methods of propagation and is not always practicable, as the seed stems develop after the rains start.

*Roots.*—The division of roots or the planting of small sods has been the method commonly used at this station for extending pasture areas. By it, a small plat of Paspalum grass can be made to furnish material for a large area whenever wanted. On account of the present poor system of transportation between the world markets and this island, this method has been found to be best adapted to Guam, where the roots are available when wanted and are not hindered by freight delays or subjected to excessive freight rates as is the case with seed. This method enables the grass to spread and grow so rapidly that it can be grazed before plantings by either of the other methods are well started.

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[26] Guam Agr. Expt. Sta. Rpt. 1916, p. 24.

The sizes of sods, or root divisions, and the distances of planting are important matters to be considered when Paspalum is planted. In general, it has been found that the smaller root divisions and a greater distance of planting may be practiced on the lower lands. Plantings have been made to find the best distance between plants and the most suitable size of root division to use in propagating Paspalum. The distances tried, with both small and large root divisions, have been 12, 18, 24, 30, 36, and 60 inches. Planting tests have shown that sods cut in pieces about 2 inches square and planted 12 inches each way give the best results on the several types of soil. The Paspalum grass should be placed in rows in such a way that it can be cultivated if weeds appear in the field. (Pl. V, fig. 2.) Close planting has reduced the bunched or tufted effect of the grass. In some of the plantings where the rows were not planted close together, cattle pasturing on the fields made paths by walking between the clumps and thus increased the bunched effect of the grass. On low, wet lands the soil forms small hummocks where the bunches of grass are and causes the field to become very rough. This is easily remedied by plowing once in 5 or 10 years and leveling the soil with a disk or smoothing harrow. Afterwards the grass grows better and more evenly than before.

Tests have clearly shown that *Paspalum dilatatum* on higher lands should be planted thickly (the distance left between the divided roots to be no more than 18 inches each way), and that large divisions of the roots should be used. About one-half acre of shallow cascajo soil on high ground near the station residence, where divisions of sod 3 inches square were placed about 18 inches apart, was well covered in four months, while grass planted in one of the goat pastures in even better soil, with small root divisions some 30 inches apart, has not covered the ground so well 11 months after planting. On the lower lands smaller divisions and a greater distance of planting may be used. One acre on which the roots were planted in rows some 5 feet apart in September, 1914, is at this time quite well covered. The grass in these latter tests has been used very little for pasture. In any case it seems advisable even on lowland to use large divisions of roots in planting and to set them not more than 2 feet apart each way, if the grass is expected to form sufficient turf to make valuable pasture in a reasonable time.[27]

Sods suitable for planting are obtained from a well-covered plat of Paspalum. Fosiños, spades, machetes, plows, or mattocks are used for taking up the sods and for cutting them into pieces of the size wanted. These pieces are then placed in bull carts, sacks, or boxes and carried to the prepared fields. Damp or rainy days are best suited for transplanting.

### COST OF PLANTING.

The cost of planting Paspalum grass seems rather high, a fact which has probably kept many people from establishing it as a permanent pasture grass. This station has been keeping records for

[27] Guam Agr. Expt. Sta. Rpt. 1916, p. 24.

FIG. 1.—WELL ESTABLISHED PASPALUM READY FOR PASTURING.

FIG. 2.—PASPALUM SODS PLANTED IN ROWS TO PERMIT CULTIVATION.

FIG. 1.—PASTURE WITH PASPALUM AREA IN CENTER CLOSELY EATEN BY CATTLE.

FIG. 2.—EFFECT OF HEAVY PASTURING WHILE GRASS IS YOUNG. PASPALUM IN FOREGROUND RECOVERING AFTER RAINS; PARÀ IN BACKGROUND KILLED.

some time on the cost of different plantings. These have run from about $15 to $25 per acre according to the land and the closeness to available supplies of roots.

Considering all expenses, including plowing and otherwise preparing the soil, hauling and setting the roots, the cost of planting per acre was about $16. This cost covers plowing at $7.50 per acre (the lowest price that the station has ever paid), disking the fields twice at $1, and digging out, hauling, and planting the roots at $7.50 per acre. While the amount seems large, the increased amount of pasture now furnished by the station's Paspalum fields is strong evidence that it is a paying proposition.[28]

At the Cotot stock farm during 1917, root divisions were planted from 12 to 15 inches each way. The actual cost of taking up the grass, transporting, and replanting alone was at the rate of $24.55 per acre on a fairly large area. This grass was planted on former virgin forest land, which had been cleared for planting at a cost of about $20 per acre. At this rate the cost of clearing virgin forests and of planting Paspalum would be close to $45 per acre. The cost would not be nearly as great on the savannas, as the only clearing required would be that of removing the sword grass. On the forest land, however, the grass became established very quickly and did not have to be weeded. Even at this large cost the experiment station has found it worth while to grow the grass and to increase greatly the area devoted to it. In Hawaii[29] it was found that by planting the root divisions at intervals of 18 inches in rows 30 inches apart, the combined operation of digging the roots and completing the planting was $11.25 per acre. This was not considered expensive since the results obtained justified the expense entailed.

A farmer can seldom prepare in one year all the area that he desires to plant in that time, especially if he has a large number of live stock. In a case like this, it is recommended that the first planting be made on well-prepared soil, preferably low soil, as close as convenient to the area to be planted. This area should not be used for grazing purposes but should be made to serve as a nursery whence an available supply of Paspalum roots could readily be had when needed. This would allow future plantings to be made at odd times or from day to day as time permitted. In this way the pasture area could be gradually increased at very little expense and the farmer would not have to neglect his regular work.

### FEEDING VALUE.

*Palatability.*—It has been stated that the best test of the palatability of pasture grasses is to let the animals choose the grass that they like the best. This can be done by turning the animals loose in fields containing different kinds of grass in the same stage of

[28] Guam Agr. Expt. Sta. Rpt. 1915, p. 21. [29] Hawaii Agr. Expt. Sta. Rpt. 1917, p. 43.

growth. The grass most readily eaten by them is the most palatable. It has never been doubted that animals like Paspalum grass, which is probably second only to Para grass of all the pasture crops on the island. On one of the insular government farms during the past two years Paspalum grass was planted in an area of probably an acre, located in the center of an exceptionally good range pasture. This ground was well established in Paspalum grass before being pastured, and is now grazed smooth as a lawn by the native and grade cattle, although a large amount of good native pasture surrounds the Paspalum (Pl. VI, fig. 1). This clearly shows that Paspalum grass is more palatable to this class of live-stock than the native grasses, and likewise that it withstands heavy pasturing well.

Close to the station barn, where the paddock consists of approximately one and one-quarter acres, Paspalum grass has furnished grazing for the past 10 years and is apparently doing as well as when first established. This paddock is used for the milk cattle at night and for the horses during the day, so that it is being continually pastured. The animals relish the grass at all times and keep in good condition when pastured on it. If not pastured for some time, Paspalum grass may become rather fibrous and tough during the dry season, as it is apparently dormant under these conditions. That it is always succulent and nutritious while being pastured is proved by the condition of animals pastured upon it compared with others on native forage.

Guam-bred cattle, both native and pure-bloods, with very few exceptions, have been maintained at this station in good condition on Paspalum pasture, without any additional grain ration. Paspalum grass has also been found well adapted to goat pastures, which are often on the hills and rocky places. At this station it has been largely planted in some of the higher goat pastures where the goats readily eat and thrive upon it.

In a palatability test in Australia [30] a great many native and imported grasses were tried to find the grass best liked by different animals. It was found that Paspalum grass, with prairie grass and Hungarian brome grass in the young stages, and with brome grass in the seeding stage, were the most palatable. Contrary to expectation, the Paspalum grass was eaten very readily, even in its mature stages. At the Cotot stock farm, where the cattle had free range upon the native grasses, it was found that they preferred the Paspalum grass to any of the grasses and kept in much better condition when pastured on it. In fact, during the last dry season, which lasted for several months, it was the only grass that stood the grazing and remained in a green condition.

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[30] Agr. Gaz. N. S. Wales, June, 1915, p. 486.

*Analyses.*—It will be seen from Table 12 that Paspalum grass contains a higher content of protein and of fat than any of the other grasses except Para grass. In these respects it compares favorably with the legumes. The following table shows that Guam-grown Paspalum grass compares favorably with that grown in other countries and that the protein content is even higher than that reported from other places.

TABLE 15.—*Some analyses of Paspalum grass.*

| Authority. | Composition. | | | | | |
|---|---|---|---|---|---|---|
| | Water. | Protein. | Fat. | Carbohydrates. | | Ash. |
| | | | | Crude fiber. | Nitrogen-free extract. | |
| Fresh green material: | | | | | | |
| Hawaii Experiment Station [1] | 73.62 | 2.96 | 0.64 | 9.19 | 11.07 | 2.52 |
| Air-dry material: | | | | | | |
| Guam Experiment Station [2] | 4.95 | 14.19 | 2.10 | 33.35 | 35.84 | 9.57 |
| Florida Experiment Station [3] | 14.30 | [7] 5.25 | 1.89 | 21.21 | 50.07 | 7.28 |
| Dry-matter basis: | | | | | | |
| Hawaii Experiment Station [4] | ..... | 11.23 | 2.44 | 34.48 | 42.21 | 9.55 |
| U. S. Department of Agriculture [5] | ..... | 8.07 | 2.70 | 31.80 | 47.61 | 9.82 |
| Department of Agriculture, New South Wales [6] | ..... | [7] 7.56 | 1.21 | 33.42 | 51.52 | 6.29 |
| Do | ..... | [7] 8.52 | 1.48 | 37.12 | 45.58 | 7.30 |
| Do | ..... | [7] 9.75 | 1.65 | 36.70 | 47.59 | 4.31 |

[1] Hawaii Agr. Expt. Sta. Bul. 13 (1906), p. 8.
[2] Average of two analyses by the Bureau of Chemistry, U. S. Dept. of Agr.
[3] Florida Agr. Expt. Sta. Bul. 18 (1892), p. 4.
[4] Hawaii Agr. Expt. Sta. Bul. 36 (1915), p. 11.
[5] U. S. Dept. of Agr., Bul. 201 (1915), p. 36.
[6] Dept. of Agr., New South Wales, Farmers' Bul. 96 (1915); p. 29.
[7] Albuminoids.

*Feeding tests.*—No definite experimental tests have been carried on with Paspalum grass as a feed because in most cases it has been used almost entirely as a pasture grass. From the analyses it can be seen that the grass has a high feeding value, being rich in protein and fats. This has proved to be the case as cattle and other stock pasturing on this grass have kept in good condition and fattened. As previously noted, the animals readily eat the grass and show a decided preference for it.

### CARRYING CAPACITY.

Paspalum grass, like Para grass, should be pastured only after the field has become fully established. This fact has been repeatedly demonstrated when it has been killed or severely set back by being too heavily pastured when young, or pastured before it has had time to develop sufficient root system to maintain the plant. In a pasture test with goats on one of the hillside pastures, an area was fenced off and pastured when the grass was only three months old. In less than three months this grass was eaten down to the roots. The other part of this field was not pastured until the end of five months,

when it had developed a strong root system and was growing vigorously. However, after the rains started the grass that had been eaten down to ground level quickly recovered and began to grow. Some time elapsed, however, before the grass could be pastured again, and it had to be weeded twice more before sufficient growth was made to enable it to take care of itself. The other field continued to furnish much pasture without any care after the first five months. Paspalum grass should not be pastured when young, yet it always stands more grazing than Para grass with less danger of being killed. (Pl. VI, fig. 2.)

It has been thoroughly demonstrated again and again that Paspalum grass will easily support two or three and in most cases several times as many cattle as the same area planted to native grasses. In fact, cattle that have free range over several hundred acres of native pasture land are invariably in poor condition and during the dry season many are lost. On the other hand, much smaller areas planted to Paspalum grass carry over a herd in good condition and without any loss because of lack of nutritive feed.

In a small pasture of about $1\frac{1}{2}$ acres, on high cascajo soil and outcropping rocks, 2 yearling bulls were kept in excellent condition with no feed other than Paspalum grass for more than 6 months. During the hot season the grass was not nearly so good and furnished much less grazing than during the rainy season. On a lowland pasture of about the same size 3 mature animals were kept for about 7 months before the grass began to decline as the result of dry weather. Tests conducted at this station showed that the value of upland pasture is not more than half that of the lowland pasture.

In a Paspalum pasture having an area of approximately $2\frac{1}{4}$ acres two work carabao have been maintained for the last 3 or more years. These animals received no other food. The grass was eaten at night and on holidays, as the animals were worked continuously on the station grounds during the day at various kinds of work, including heavy plowing. The animals have kept in good work condition, and the stand of grass has not been injured in the least.

This station has quite an area of Paspalum pasture at the Cotot stock farm. It has been estimated that this grass will carry from 2 to 3 head of cattle per acre the year round on the better soils, and will keep them in good condition at all times. When the foreman of the above place was asked what grasses he would plant for cattle on his own ranch in Guam, he replied: "I would plant both Para grass and Paspalum grass, as I think they would both fill an important place on every ranch; but if I were limited to only one kind, I should certainly choose the Paspalum grass, because it stands heavier pasturing and more dry weather than the Para grass is able to

stand." It is estimated that one of the paddocks situated on low ground near the station has been supporting more than one animal to the acre for the past 10 years.

In the Tweed district (New South Wales, Australia), it is said that an acre of Paspalum pasture will support one dairy cow the year round.

In Hawaii it may be said that there is a different capacity for each square mile of pasture. At the Princeville plantation, at an elevation of 300 to 800 feet, with 60 to 100 inches of rain, the carrying capacity has been one steer per acre for three years in one paddock of 40 acres. In a paddock of 450 acres, 500 head were carried for one year, then 180 head for 10 months, then after 2 months 100 head were turned in. More were added until full capacity was reached. The carrying capacity varies with age and amount of growth of the grasses when the cattle are turned in, and also with precipitation.[31]

*Improving pastures.*—While Paspalum grass as it ordinarily stands is very superior to native grasses, it can be improved in three ways: (1) By resting; (2) by manuring; and (3) by renovating old fields. It is not absolutely necessary to rest Paspalum pastures, but where possible this should be done because it helps the pasture to a marked extent.

A resting period on an average of two months each year would materially help the development of the plant and give it a chance to get well started again before it is pastured heavily. Barnyard manure applied thinly as a top-dressing will greatly repay all the labor that it takes to make the application. The manure adds organic matter to the soil and prevents it from becoming badly puddled during the wet season and from compacting and cracking during the dry season. The first makes a better seed bed for the roots and allows the air to circulate in the soil; the latter keeps the plants from losing moisture through evaporation from the cracks and also prevents the breaking of the roots when the ground cracks open. The manure adds nitrogen to the soil, which is generally deficient in this element. The nitrogen causes the plant to make a quick growth and gives it a dark green color.

The oldest fields at this station are still producing a large amount of pasture, though they have been grazed for 10 years. In time it may become necessary to renovate them. As an experiment one of these pastures was plowed, harrowed well, and then planted to jack beans and cowpeas. No cultivation was given other than that of removing the weeds. The grass grew again, a good stand was secured after the cowpeas and jack beans were harvested, and it has since been furnishing excellent pasture. The roots of Paspalum grass are very fibrous and so thick that in time the pastures will probably have to be plowed to break and loosen the roots. This will enable the grass to get another good start.

[31] Hawaii Agr. Expt. Sta. Bul. 36, pp. 16, 17.

### SPREADING TO OTHER FIELDS.

In Guam very little trouble has been experienced with Paspalum grass spreading to adjoining fields. For several years Paspalum grass which was kept for propagation, has been grown on a large plat between a plat of Para grass and a cultivated field. While it has held its own in every respect, the grass has shown no tendency to spread into the adjoining plats. However, this grass has never been pastured. It has been noted that where trampled in pasturing the grass spreads to a certain extent. It is also possible that it may be spread by means of seed that is carried by water. Paspalum and Para grasses were planted in adjoining plats in a cattle pasture at Piti about four years ago. After about two years the Para grass was replaced by native grasses, which in turn have been replaced by the Paspalum grass. These plats were never heavily pastured, and it is assumed that the Para grass was very palatable and consequently killed by the live stock. Paspalum grass, being more aggressive than the native grasses and being continually trampled, has spread over the whole pasture and forced out the native grass, which had become fairly well established.

On the island of Kauai it has been found that water grass planted at distances of 6 to 10 feet apart both ways in dense areas of the worthless Hilo grass (*P. conjugatum*) will crowd out and entirely displace the Hilo grass within 2 or 3 years.[32]

It has been reported in Porto Rico that the Para grass has crowded Paspalum grass out of the fields. In cultivated fields in Guam no trouble is experienced with Paspalum grass, which is easily killed by constant cultivation.

### SEED PRODUCTION.

Commercial seed at present comes almost wholly from Australia, where it seems to mature better than in most places. However, it has been stated that in the Union of South Africa the grass spreads during rains by seed, which is borne by the water, and that many of the seed are viable. In Guam the seed stems are produced during and toward the end of the rainy season. When the grass is closely pastured, it produces few, if any, seeds. The seeds are mostly sterile and often immature. It is seldom that the germination is over 25 per cent. In the various seed heads of the plants the individual seed matures very unevenly. This causes many unripe seed to be harvested unless special attention is given when gathering it. Commercial seed is costly and should be selected with great care. Commercial seed, which will give a strong germination of 50 per cent, is considered very good. By running seed through a fanning mill and a screen the immature and light seed will be blown out and only the heavier seed left. This process insures a higher rate of germination,

[32] E. V. Wilcox. Tropical Agriculture, New York, 1916, p. 314.

but gives a smaller amount of seed to be sown per acre. Even by winnowing in the open air upon bamboo trays and pandanus mats, as is customary with palay (unhulled rice), seed improved for planting can be secured. Profitable seed production on a large scale will not be successful, as the seed is not plentiful enough under Guam conditions.

### INSECTS AND DISEASES AFFECTING PASPALUM.

Paspalum grass is little troubled by any kind of pest. No diseases are known to affect this grass in Guam. The rice bug of India (*Leptocorisa varicornis*) works to some extent on the seed and seed stems, and a leaf folder is occasionally found on the grass blades. Grasshoppers are present also in considerable numbers at certain seasons of the year. None of these insects does any apparent serious damage to the Paspalum grass in the pastures.

## SUMMARY.

Most native pasture grasses and forage crops in Guam have a poor feeding value.

For the past 10 years the station's experience with native grasses in live-stock work has clearly shown the desirability and necessity of substituting for them proved introduced grasses, such as *Panicum barbinode* and *Paspalum dilatatum*. Both of these grasses are adapted to Guam conditions, being remarkably vigorous growers during the wet season, and on the other hand, possessing special drought-resistant qualities which render them valuable during periods of extremely dry weather. This latter is true particularly of Paspalum grass.

Para grass was introduced into Guam by the Guam Agricultural Experiment Station in May, 1910, from the Hawaii Agricultural Experiment Station, where it had been brought from the Fiji Islands in 1902. Para grass is a coarse perennial grass having prostrate runners. The younger stems grow upright when the ground is fairly covered with grass. It attains a height of 2 to 15 feet. It is a good soiling crop, and may be pastured very profitably if this is done judiciously. It is readily propagated by seeds, roots, cuttings, and by whole stalks. Para grass gives high yields on lowlands, the yields being increased when the field is given an application of barnyard manure or commercial fertilizer. In palatability tests, Para grass was liked better by the animals than any of the other grasses tried at this station.

Both Para and Paspalum grasses should be well established before they are pastured. Paspalum grass will stand much heavier grazing at all times than will Para grass. Para grass will, however, easily carry one animal per acre the year round.

Paspalum grass was first introduced into Guam in 1909 by the experiment station. Seed was obtained from the United States

Department of Agriculture. Paspalum grass is a perennial having a deep, fibrous root system, and unless planted close together, it grows in bunches. It is propagated by seeds and cuttings, but preferably by root divisions, which should be planted about 1 foot apart. It is principally a pasture grass and produces a large amount of pasture during at least nine months of the year. On the better soils it will support several times as many cattle as the native grasses will carry. It is adapted to a greater range of soil conditions than any other grass tested by this station. It grows best on the rich, moist lowlands, but will succeed on comparatively poor and rocky soils. The carrying capacity of Paspalum grass is high. It has been estimated to pasture easily one to three animals per acre the year around on ordinarily good soil.

Para and Paspalum grasses both have a high content of protein and fat as is shown by chemical analyses, and a high feeding value as is shown by feeding and pasture tests. Every farmer in Guam should have either Para grass or Paspalum grass, or both, on his farm to furnish forage for his live stock.